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EDITORIAL.

ITEMS AND NOVELTIES.

Heyl's Machine for making Paper Boxes.—BY HECTOR ORR.*—More than seven years ago, my friend Mr. H. R. Heyl determined to make rectangular paper boxes by machinery. I heard of his intention soon after the inception of the idea, and I promised to introduce the contrivance at a monthly meeting of the FRANKLIN INSTITUTE as soon as it was presentable. I heard of the progress of the enterprise from month to month, and from summer to winter; then into the second year; the third, and then onward rather indefinitely. At length, in January, 1871, Mr. Heyl brought me this box which I now show you, as one of the first lot actually made by the long-sought machine. We did not then exactly fix a day for bringing it here, yet felt sure that it would arrive soon. But the months began to speed along again; summer arrived; the equinox and the September meeting were true to their accustomed dates; the paper-box automaton, however, still continued to "turn up missing;" until I began to suspect that the express wagon with its coveted freight, instead of reporting at the Hall, North Seventh street, had sped away into the "land of promise" once more.

* Read before the Franklin Institute, September 17, 1873.

That machine (which is not here, but which I hope we all shall have the opportunity to see sometime) was intended to make rectangular boxes by paste, paste-board and slips of paper, applying much of the means formerly used for the purpose, and imitating in a surprising manner even the motions of the human operator. The box, as you may prove, is both neat and strong, and can be made at a rate full *ten times* as fast as that of the most expert girl or boy. I have seen several—yes, many—ingenious machines through the past fifty years, topping off thus far perhaps with the Bullock Printing Press, but I must admit that among them all this automatic Paster deserves its full room in the front rank, for its series of complex movements following in most attractive harmony to a triumphant result.

This admirable contrivance, however, the child of patience and perseverance, is already measurably superseded. (I hope yet to see it fenced in like the old Independence Bell, in the parlor of the owners of the patent; but for the present we must turn from it.)

About the middle of last February, I found at my office a notice that the "improved" Box-making Machine would be running that afternoon in West Philadelphia. It was a day of most ungracious weather, such as even the clerk of Probabilities is unable to specify. Its the temperature just between freezing and thawing, and the surface of ground covered with dirty snow. But what is two miles of snow slush as an impediment, when there is an ingenious machine to be seen at the end of the journey? I can say that "I conferred not with flesh and blood" as to my conduct, but within the next hour was on my way to the factory, at whose threshold I met Mr. Heyl, who declared the burden of the day completed by my arrival. I there saw a machine making such boxes as *this*, at the rate of 3,000 per hour. It is a match box; and I saw the slips of wrapper lifted singly and shaped; then fastened by delicate staples of iron wire, which were made and riveted by the machine; and then said enclosures were touched with glue and sprinkled with sand, and fell down before me ready to be filled with matches!

This machine dispenses altogether with paste in the formation of the box—a great desideratum on more than one account. For besides the gain in speed thus secured, the getting rid of the moisture identified with the paste is a most important achievement; for the delay in drying the box, caused by damp weather, often frustrates the shipment of large invoices, if not a whole season's supply, of goods. We have just experienced a spell of moist weather in which pasted boxes

might actually mildew before they would dry, and in a damp state they would injure if not ruin the goods packed in them. In pasted boxes, also, under a high temperature and damp atmosphere, insect life is generated, which destroys the proper strength of the box and also seriously damages confectionary or dried fruit contained therein.

These were the considerations which induced Mr. Heyl to modify his first machine, and through various changes he now presents it as making a neater and stronger box than that made by hand, and produces by one machine the amount of work hitherto requiring the labor of *seventy-five* persons.

Besides the special purpose of this invention, in thus greatly adding to the supply of an article indispensable to much of the small wares of trade, the improved mode of fastening the edges offers new proof of the *power of impact* exerted at a right angle with the surface. These minute staples are composed of fine soft wire hardly more rigid than a thread of waxed sewing silk. This wire is wound on a spool, from which the proper length is drawn for each box, and the staples are formed and brought each to its place at right angles with the box material, and at the right moment are made to puncture the wrapper or board, and are immediately clinched on the opposite surface. I think the most adroit set of fingers among us would fail to force or coax the point of this wire through even a thick wrapper, in less than several minutes, while this machine, besides all its other work, does this sixty times per minute. It furnishes one more instance of an act which,

> " *When* it is done,
> 'Twere well it were done quickly."

Indeed, unless it be done quickly, it cannot be done at all. If this admission shall furnish some future annotator of Shakspeare with an argument to prove that his idol knew all about the making of paper-boxes, it will not be more far-fetched than some of the feats already ascribed to him.

I thus place before the Institute a full seven years' task completed, and that completion embracing an emphatic triumph of patience and skill; presenting a useful branch of business advanced in style and strength, and whose production is multiplied full seventy-five times.

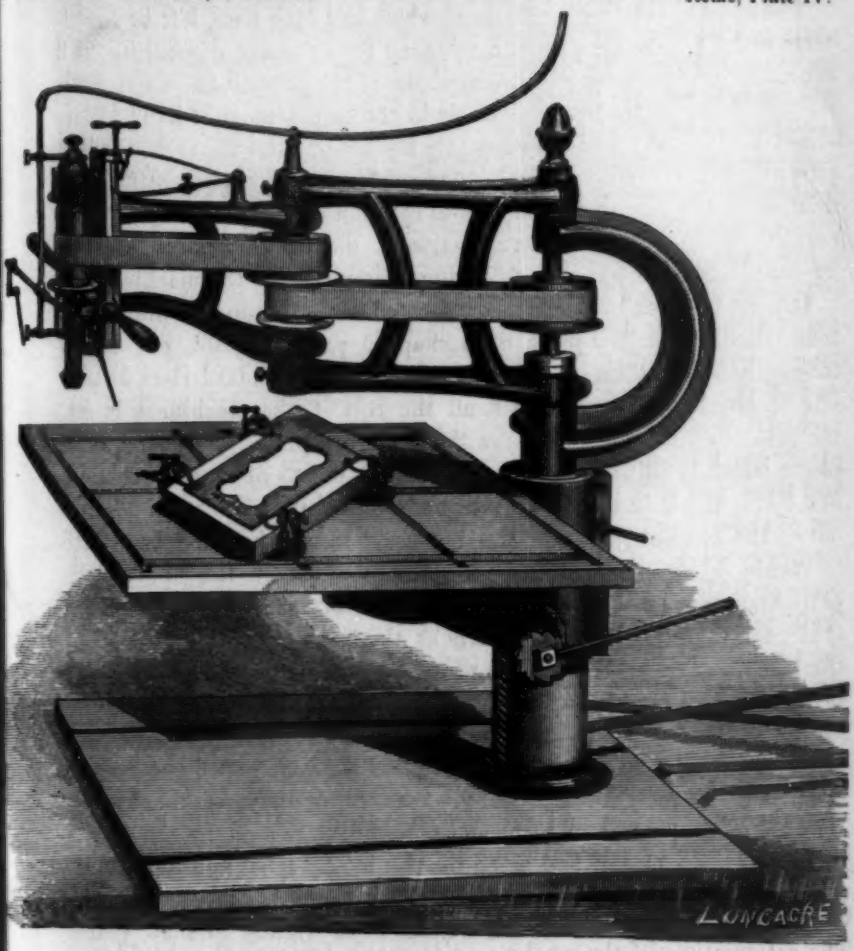
And now I shall give place to another *talking* machine, which I expect shall *speak for itself;* I having that intruding peculiarity which excels in speaking for others.

The Gear Stone Cutting Machine.—At a recent meeting of

the Franklin Institute, Col. A. S. Gear gave a description of the machine of which the accompanying plate gives an illustration.

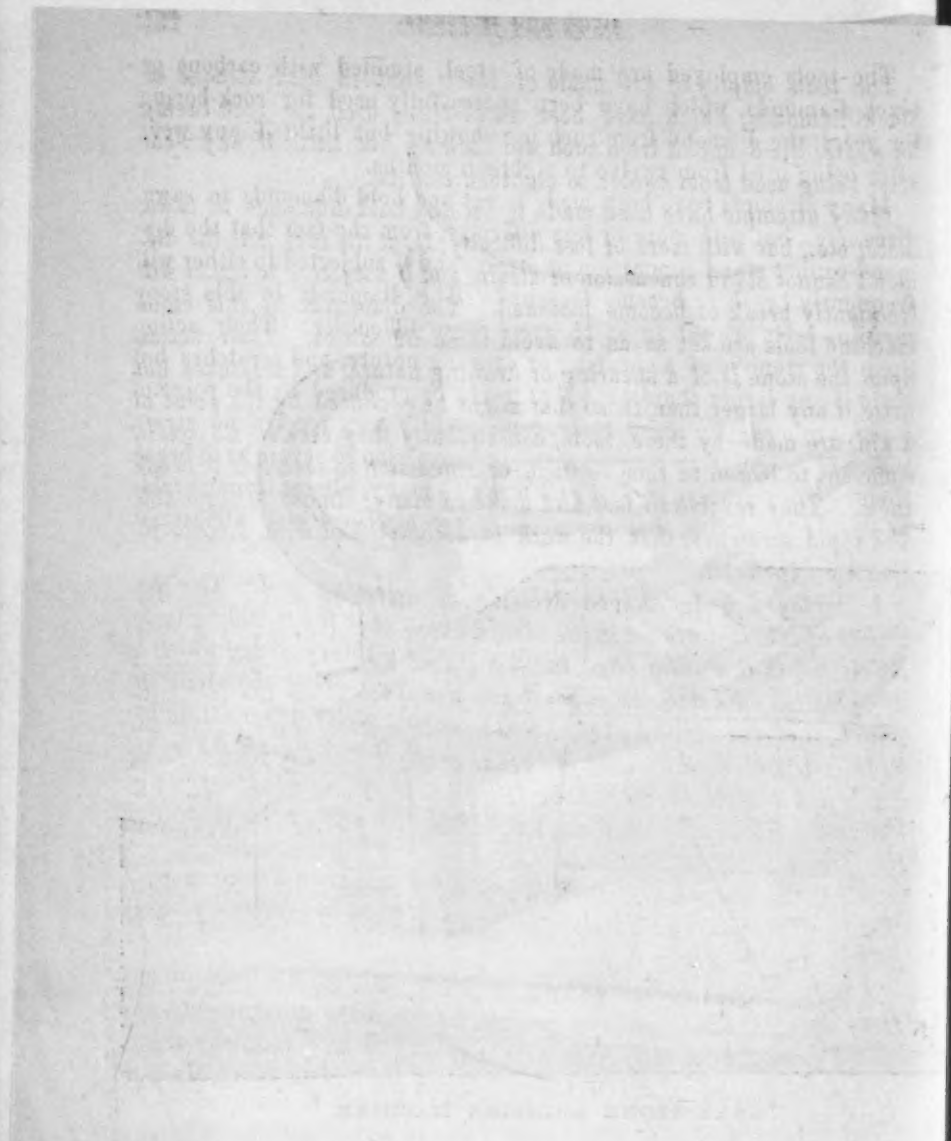
The speaker referred to the need which had long been felt by architects and builders for proper machinery for dressing, decorating and ornamenting stone, by which something of the present excessive cost, which has heretofore been inevitable in the employment of hand-labor, might be avoided; and consequently the use of stone for architectural purposes become more general. After a brief enumeration of the difficulties in the way of the successful solution of the problem, and the reasons which prompted the selection of the diamond as a cutting agent, the speaker gave the following description of the machine:

It rests upon and is strongly connected with an iron bed-plate as a foundation. The bed-plate is in shape a parallelogram, not much longer, however, than its width. A heavy iron standard rises at one end of the bed-plate, to which all the rest of the machinery is attached. A short distance above the lower bed plate is a second bed-plate, which is adjustable, up or down, by means of a rachet-wheel and lever, and is in the easy control of the operator, or can be turned out of the way entirely when it is necessary to use the lower bed-plate for heavy work—the lighter work being all done on the upper bed-plate or table. Above this bed-plate, and attached to the upright shaft, are the more important parts of the machine. This portion of the machine is in two general parts, strongly and firmly made, and provided with pulleys that give great rapidity to the cutting or moulding tools, the motions of which are all circular or rotary. This part of the machine, for purposes of description, may be called the human arm, its entire movements strikingly resembling those of the human arm, the most perfect and the most beautiful motion in the whole realm of nature or art, and being far the most varied and important. At the extreme end of the arm is its hand, which firmly grasps the various tools it operates with, and holds them rigidly to their place. The articulations of the machine, so to speak, being at the shoulder—its shaft attachment—and at the elbow, where the two parts are connected together, and at the wrist, where the hands grasp the tool, the movement of the tool is completely, and with the utmost ease, under the control of the operator. A pattern is used in cutting ornamental work, which is simply an outline of the design desired. Both the pattern and material being operated upon, are fastened to the table by adjustable clamps. Every little adjustment has been perfected with a view to rapid changes, and the spindle containing the cutting tool may be run at almost any angle.



GEAR STONE DRESSING MACHINE.

commission appointed by the United States Government to inquire into the causes of steam boiler explosions, in order to determine by actual experiment the best form and construction of safety valves which shall operate automatically in relieving the boiler from the



work, which is simply an outline of the design desired. Both the pattern and material being operated upon, are fastened to the table by adjustable clamps. Every little adjustment has been perfected with a view to rapid changes, and the spindle containing the cutting tool may be run at almost any angle.

The tools employed are made of steel, studded with carbons or black diamonds, which have been successfully used for rock-boring for years, the diamond from such use showing but little if any wear after being used from twelve to eighteen months.

Many attempts have been made to set and hold diamonds in saws, discs, etc., but with more or less difficulty, from the fact that the diamond cannot stand concussion or strain, and if subjected to either will frequently break or become loosened. The diamonds in this stone machine tools are set so as to avoid these difficulties. Their action upon the stone is of a shearing or drawing nature, and scratches but little if any larger than those that might be produced by the point of a pin, are made by these tools, consequently they receive no strain sufficient to loosen or remove them, or concussion so severe as to break them. They revolve so fast and make so many, almost innumerable and rapid scratches, that the work is accomplished with almost incredible expedition.

I employ a wedge-shaped dressing or surfacing tool. The diamonds in this tool are set in the same manner as in the moulding tools. Above the thin cutting edge there is placed a rotary wedge which in its operation cuts into the edge of the stone, removing the stone the thickness of the cutting edge. After cutting under a mere trifle the wedge strikes it and splits or breaks it off, it making no difference whether a quarter of an inch or four inches in thickness are to be removed. Stone may be dressed with this tool just as it comes from the quarry.

All work required or desired in producing ornamental stone-work—in a word, everything heretofore produced in wood by machinery—may now be done in stone.

I have obtained several patents in this country on the machine and tools—several have also been granted by European governments, and others applied for. The machine is now owned by a company organized under the laws of Massachusetts, called the "Gear Stone Machine Company."

The Commission on Steam Boiler Explosions.—The following official information, upon a subject of much interest to engineers and the public in general, has recently been made public. The commission appointed by the United States Government to inquire into the causes of steam boiler explosions, in order to determine by actual experiment the best form and construction of safety valves which shall operate automatically in relieving the boiler from the

pressure of the steam, or with certainty to automatically prevent any increase of pressure above that at which the valve shall be set, invite persons claiming to have valves of superior efficiency to submit one to the commission for examination and testing. All valves presented must have an area of five square inches in their discharge openings, and the flange for attaching to the boiler must be eight inches in diameter, flat face without bolt-holes; valves to be sent, charges prepaid, and communications on the subject addressed to Addison Law, Supervising Inspector, No. 23 Pine street, New York city, before October 10th, 1873.

The commission at a recent meeting held at Washington, decided to call for co-operation and advice, in the performance of their allotted duties, upon engineers, inventors and scientific societies. The points upon which the commission solicit information are the following: 1. Explosions caused by the gradual increase of steam pressure. 2. Those caused by low water and over-heating of the plates of the boiler. 3. Those caused by the deposit of sediment or incrustation on the inner surface exposed to the fire. 4. Those caused by the generation of explosive gases within the boiler. 5. Those caused by electrical action. 6. Those caused by the percussive action of the water in case of rupture of the boiler in the steam chamber (the Clark and Colburn theory). 7. Those caused by the water being deprived of air. 8. Those caused by the spheroidal condition of the water. 9. Those caused by the repulsion of the water from the fire surfaces or plates.

Communications intended for the commission, upon these or related matters, should be addressed to Mr. Geo. W. Taylor, the Secretary of the Experimental Commission, at the Treasury Department, Washington, D. C.

The St. Louis Bridge.—A local paper affords the material for the following concerning the progress of this undertaking:

The difficulties to be encountered in putting in the connecting tubes to complete the span of the first arch of the bridge are not generally understood, hence there is a little surprise amongst a large portion of the public on account of the delays which have occurred. At present the weight of the superstructure is supported by the cables, and whilst that is the case, the expansion and contraction of the tubes by heat and cold is of no consequence, but when it comes to putting in the last tubes, expansion and contraction play an important part. When

the connection is once made and the supports removed so that the arch is self-sustaining, a new element is introduced—the contraction due to pressure.

When the cables are slackened, the arch at the centre will, from this cause, settle about three inches. Provision has been made for this by increased length in the tubes, all the calculations being based on a temperature of sixty degrees. At that temperature it is known to the sixtieth of an inch what would be the intervening space between the approaching tubes, and the last points have been diminished accordingly.

Only once since the workmen have been ready to put in these last tubes has the temperature been favorable. On one morning recently, the conditions were favorable, but owing to some inexplicable tardiness on the part of the workmen, the opportunity was lost. One tube was put in and fitted to a nicety. In the meantime the sun shone on the bridge, and when it was attempted to place the other tube, it would not go entirely to its place, being about a thirtieth of an inch too long, on account of the expansion of the tubes in place. An attempt was made to drive it into place with sledges, but without effect. In consequence of not being able to put the second tube in place, the first one had to be taken out again, and a more favorable opportunity waited for.

The prospect being that a delay of several days would occur before the exact temperature required would be obtained, it was determined to try a little strategy in the case by reducing the temperature artificially. Accordingly, about 45 tons of ice were applied to the tubes and bound on by many yards of gunny bagging, forming perhaps the most extensive ice poultice ever used. On the afternoon of the same day the expansion had been reduced about two inches, and our informant concludes it was expected that in a few hours more the contraction would be sufficient to admit of the tubes being put in place. The successful execution of this experiment we hope to chronicle in a future number of the Journal.

The East River Bridge.*—The New York tower of the East River Bridge has nearly reached the level of the roadway, and the view now obtained from its summit is the same as will be had from the bridge when completed. The whole of New York, and the greater part of Brooklyn and Williamsburgh, constitute but a portion of the

* The Iron Age.

prospect which is seen from this elevated position. On a clear day one can easily see some of the villages on the Hudson, portions of New Jersey, Staten Island, and New York harbor. On the Brooklyn side, the three piers which extend above the roadway, and are to support the cables, have been brought up to the springing line of the arches.

The laying of masonry on the New York tower at present proceeds but slowly, on account of the iron work necessary at this stage of the construction. Nearly a week is now consumed in laying a single course of masonry. At the seventieth course the use of iron cramps was begun. The cramp consists of a bar of round wrought iron, about 1½ inches thick and three feet long, three inches at each end being turned down at a right angle to its length. Its office is to bind together two adjacent stones. A hole is cut in the top of each stone, into which the ends of the cramp are inserted, and a groove is cut on the upper surface of the stones upon which the cramp lies. The holes into which the ends of the cramp are inserted are filled with cement, and a strong bond is thus secured. Thirty-two of these cramps were placed in the seventieth course, and the number has been gradually increased as the tower was carried upward; the seventy-ninth course contains sixty-four cramps. They are laid parallel to the face of the tower, that is, at right angles to the direction of the bridge. Their object is to counteract the tendency of the tower to spread where the weight of the bridge comes to bear upon it.

To provide still further against the tendency of the tower to spread, the four courses below the roadway, viz.: the 76th, 77th, 78th and 79th are strengthened by strong eye-bars, consisting of flat iron five inches in width by one in thickness. There are two of these in each course, one in the front and the other in the rear, each extending nearly the whole length of the tower. The bar is secured to the masonry at each end by pins three inches thick and two feet long, passing through an eye in the bar, and extending nearly a foot into the masonry above and below. Each bar really consists of two bars joined in the centre and firmly bound together by iron wedges. A groove is cut in the upper surface of the course of masonry on which the bar lies, for its reception, so as not to disturb the level of the course above.

In the 79th, 80th and 81st courses are laid a series of compound steel bars ten inches wide by two in thickness, designed to prevent the swaying of the bridge from side to side from the action

of the wind or any other cause. There are two of these bars in each course, one at each end. Each bar is composite, consisting of three sections connected together at their ends by splice plates and bolts. The outer one of the three, or that which projects from the face of the tower, is straight, and has such an angle with the face that, if continued, it would strike the bridge about half way across. The middle section is curved, and the third section, which is spliced to this one, projects sufficiently beyond the rear of the tower to allow a pin to pass through an eye cut in its extremity. It makes the same angle with the rear of the tower as the front section does with the face. Each of these compound bars weigh 2½ tons. As before stated, there are three tiers of such bars at each end of the tower; their ends project beyond the masonry, and a pin six inches thick driven through the eyes in each set of projecting ends secures them firmly to the tower, and combines the three tiers at each end of the tower in one powerful link. Two heavy cables are fastened to these bars, one to each link. Each cable proceeds from its link to the centre of the other edge of the bridge, and then passes over to a corresponding link on the opposite tower. A series of smaller irons, intended to supplement these bars, are also fixed in the tower, and from these are to extend cables to a point half way between the middle of the bridge and the shore.

A series of eye bars extend through the tower a few courses below the roadway, and parallel to the axis of the bridge; they are directly under the future position of the bridge trusses, and are to be connected with tension cables, which extend diagonally upward to the lower surface of the bridge. The function of the latter is to give a greater degree of rigidity to the structure. The connecting walls of the tower are cut at the 80th course, in order to receive the trusses which rest upon and fit into that course. The tower, it will be remembered, consists virtually of three towers joined by connecting walls. At the 81st course the latter are discontinued, and the three piers carried up independently, as can now be seen in the Brooklyn tower. The centre pier of the three is built entirely of dimension stone, even the backing being constructed in this manner. A very great degree of strength is required of this pier, inasmuch as it is to support two of the main cables, and is narrower than the two exterior piers, each of which support but one cable. The latter, however, are also to be constructed largely of dimension stone. There are now about forty men employed on the New York tower; of these ten are

engaged in cutting the holes and grooves in the stone, and five in laying the masonry.

As soon as the 80th course is completed the method of carrying on the work will be completely changed. The old boom derricks will be taken down, and their places supplied by a pair of balance derricks for the exterior piers and a traveling crane for the middle pier. The reason for not using a derrick in the latter case is that it would be necessary to have a well hole in the centre of the pier, in which to place the mast, and the pier would be thereby weakened. As great strength is required in this place such an evil is avoided by the use of a traveling crane instead of a derrick. Both the crane and one of the derricks are now completed, the other derrick being nearly ready. The boom of each derrick is thirty feet in length, and the span of the traveling crane is about eighteen feet. The new engine for hoisting stone, etc., to the top of the tower is also ready. It has two hoisting drums, both on the same shaft, and while one drum is engaged in hoisting to one end of the boom, the other is unwinding its rope and allowing the hook to descend at the other end of the boom. As soon as the 80th course is laid all the machinery formerly used on the tower and the docks will be rapidly dismantled, and the new appliances substituted. Every portion of the machinery exposed to heavy strains is tested once every day, and as the work approaches completion, all the calculations connected with it are made with greater exactness.

The four anchor plates for the Brooklyn anchorage are already in position. They are laid at a depth of 24 feet below the surface of the ground, and six courses of masonry have been laid upon them. About twenty buildings have been torn down to make room for the anchor walls. In all the calculations respecting the strength of the various portions of the bridge one-sixth of the theoretical strength has been taken as the maximum, in order to leave a wide margin of safety.

The Vienna Patent Congress.—The following is the text of the resolutions adopted by the recent International Patent Congress which met at Vienna: 1. The protection of inventions should be guaranteed by the laws of all civilized nations, because, (a) The sense of right among civilized nations demands the legal protection of intellectual work. (b) This protection affords, under the condition of a complete specification and publication of the invention, the only prac-

tical and effective means of introducing new technical methods without loss of time, and in a reliable manner, to the general knowledge of the public. (c) The protection of invention renders the labor of the inventor remunerative and induces thereby competent men to devote time and means to the introduction and practical application of new and useful technical methods and improvements, and attracts capital from abroad, which, in the absence of patent protection, will find means of secure investment elsewhere. (d) By the obligatory complete publication of the patented invention, the great sacrifice of time and of money which the technical application would otherwise impose upon the industry of all countries, will be considerably lessened. (e) By the protection of inventions, secresy of manufacture, which is one of the greatest enemies of industrial progress, will lose its chief support. (f) Great injury will be inflicted upon countries which have no rational patent laws, by the native inventive talent emigrating to more congenial countries, where their labor is legally protected. (g) Experience shows that the holder of a patent will make the most effectual exertion for a speedy introduction of his invention.

2. An effective and useful patent law should be based on the following principles: (a) Only the inventor himself or his legal representative, should be entitled to a patent. (b) A patent should not be refused to a foreigner. (c) It is advisable, in carrying out these principles, to introduce a system of preliminary examination. (d) A patent should be granted either for a term of fifteen years, or be permitted to extend to such a term. (e) Simultaneously with an issue of a patent a complete publication of the same should take place, rendering the technical application of the invention possible. (f) The expense of obtaining a patent should be moderate; but in the interest of the inventor, a progressive scale of fees should be established, enabling him to abandon, when convenient, a useless patent. (g) Facilities should be given by a well organized patent office to obtain in an easy manner the specification of a patent, as well as to ascertain what patents are still in force. (h) It is advisable to establish legal rules, according to which the patentee should be induced, in cases in which the public interest may require it, to allow the use of his invention to all responsible applicants for an adequate compensation. (i) The non-application of an invention in one country shall not involve the forfeiture of the patent, if the patented invention has been carried into practice at all, and if it has been rendered possible for the inhabitants of such country to purchase and make use of the in-

vention. (k) In all respects, and particularly as regards the proceeding in the granting of patents, the Congress refers to the English, American and Belgian patent laws, and to the draft of a patent-law prepared for Germany by the Society of German Engineers.

3. Considering the great difference in patent administration, and the altered international commercial relations, the necessity of reform is evident, and it is of pressing moment that the governments should endeavor to bring about an international understanding upon patent protection as soon as possible.

4. The Congress empowers the preparatory committee to continue the work commenced by this first International Congress, and to use all their influence that the principles adopted be made known as widely as possible, and carried into practice.

5. The committee is likewise authorised to endeavor to bring about an exchange of opinions on the subject, and to call, from time to time, meetings and conferences of the friends of patent protection.

6. To this end the preparatory committee is hereby appointed to act as a permanent executive, with power to add other members to their number, and to appoint the time and place for the next meeting of the Congress, in case such a meeting should be considered necessary for the promotion of the foregoing resolutions.

Phosphor-Bronze.—The industrial exhibitions abroad have afforded an opportunity for the display of many interesting and valuable efforts in behalf of industrial progress. As of special note we may refer to the display of objects in phosphor-bronze, of which much has lately been said.

To recall this subject to mind it will be well to state that the metal in question is a new kind of bronze, patented by Messrs. Montefiore and Kunzel, and is composed of varying proportions of copper, tin and phosphorus. The alloy is capable of being made tough and malleable, or hard, at will, according as the proportions of the materials are varied. The presence of phosphorus in its composition permits of making very clean and sharp castings. Dr. J. R. Mann, on behalf of the Society of Arts, gives the following list of exhibited objects in this metal, which affords an excellent illustration of the various uses to which it is designed to put it. The list comprises heavy bearings of machinery, cog wheels, guns and cartridge cases, wire, tuyeres for blast furnaces, and ornamental castings of various kinds; tools and appliances, such as hammers, knives, scissors, hinges, locks, keys, bells, netting, seives, &c.

A contemporary (*Iron*), referring to the subject, remarks amongst other things; the new alloy which has been recently brought before the public is likely to be much patronized, especially in manufactures where steel is useless or dangerous. The reasons given by the patentee are that it can be made, according to the wish of the operator, more ductile than copper, as tough as wrought iron, or as hard as steel; it possesses great fluidity; its homogeneity is complete, and its grain is as fine as that of cast-steel. It may be perfectly controlled to suit any particular purpose for which it is intended, and it can be made either hard or soft, tough or brittle, and its ductility, elasticity, or hardness can be regulated with the most perfect accuracy. Unlike other alloys it can be re-melted without any material loss or alteration of its quality, while heavy steel castings, when worn out or broken, are comparatively worthless.

A great variety of objects hitherto worked in iron and steel may now be cast in the new alloy, and in a great many cases they require only a polish to make them ready for use; besides which they do not corrode as do articles of iron or steel. The great fluidity, compactness and fine grain, as also the beautiful color of the metal, especially recommend it for the decorative art, while the perfection of the castings greatly reduces the cost of chasing and finishing. This alloy stretches more than copper, or any of its ordinary compounds, and plates of it have been reduced by a single cold rolling to one-fifth of their thickness, the edges remaining perfectly sound and without crack.

By order of the Prussian Ministry of Commerce, experiments have been made with the various kinds of phosphor alloy, the object of which was to ascertain the resistance of the metal to repeatedly applied strains or pulls, and also to bends of a given force.

The first bar fixed on the stretching machine resisted 408,230 pulls of 10 tons per square inch, while a bar of ordinary bronze broke before the strain of 10 tons had been reached. Another bar withstood 147,850 pulls of 12½ tons per square inch. Still more favorable results have been obtained on a machine by which the test bar was bent as often as 40,000 times per day. In this instance it resisted 862,980 bends of 10 tons per square inch, while the best gun metal broke after 102,650 bends of the same force. Another bar which was being tested withstood 1,260,000 bends of 9 tons force per square inch without showing signs of weakness.

The St. Louis Tunnel.—The construction of the great railroad tunnel in St. Louis is steadily progressing. Work upon this enterprise was begun last November, but owing to an inclement winter very little progress was made until about the middle of March, since which time the progress made has been satisfactory even to its most sanguine friends.

The span of the arches of the tunnel, of which there are two, is fourteen feet clear, and the height seventeen feet. The arches have a depth of five lengths of brick springing from a wall of solid stone, whose foundation is six feet thick; the side walls are five feet thick to the spring line, above which the thickness of the wall is four feet; the centre wall is three feet in thickness. All the brick-work and masonry is set in hydraulic cement.

The work thus far done is in figures as given by a local authority: 12,500 yards of stone masonry; 2,500 yards of brick masonry, and 95,000 yards of excavation. The prospects are that the bridge and tunnel will be opened simultaneously.

A Valuable Record of the International Exposition.—An editor of London *Engineering* is constantly at Vienna, with an assistant editor, and the enterprising publishers of that periodical are proposing to expend several thousand pounds upon the illustration of the articles prepared by them in reference to the great exhibition.

This valuable material will subsequently be published in book form, immediately after the close of the *Ausstellung*. We shall look for its appearance with very great interest.

Editorial Correspondence.

To the Editor of Journal of the Franklin Institute:

Dear Sir,—My attention has been called to an article of Mr. Mott on "Lightning and Lightning-rods," published in the August and September numbers of the "Journal," which contains many theories and notions at variance with those published by myself about a year since.

Mr. Mott says: "Thus his Majesty's ship Dictator was struck and damaged by lightning at Martinique, in the year 1794, during fine weather and a clear sky."

When effects are produced without cause miracles are wrought, and

this is the latest recorded instance of a miracle. It is difficult to understand how any one who possesses any familiarity with the laws governing the propagation of the electric current, can believe that such an occurrence ever took place.

"The return stroke often kills men and animals, or destroys buildings which are at the time at a great distance from the place where the direct discharge occurs."

I have no hesitation in emphatically asserting that there is no such thing as a "return stroke" in an electrical discharge. There is a general inductive disturbance, or recombination, whenever disruptive discharge takes place; but it is simultaneous with the discharge, and not an after result, and never "kills men and animals or destroys buildings which are at the time a great distance from the place where the direct discharge occurs."

In speaking of the effect and virtue of points over knobs or balls, my experiments show the very opposite of what he states, to be true, and consequently I can neither appreciate nor subscribe to his remark or conclusion that, "Hence it (a point) may prevent a disruptive discharge which might otherwise occur."

On the evening of the 4th of July, 1872, a thunder-storm passed over this city. Within the space of an hour over one hundred buildings were struck by lightning, or the effects of the lightning were noticed in over a hundred different places, leaving out many, probably a greater number, where the effect was unnoticed, or no damage produced. The discharges or flashes of lightning occurred as often as once per second during a portion of this hour. There were at least five thousand pointed rods in this city, and how much did they "produce an escaping current," or "prevent the accumulation of electricity," or neutralize the charged cloud"? Probably they did their level best, and prevented a discharge occurring oftener than once per second. The above example affords a practical illustration of the ability of points to silently discharge the accumulated electricity of the clouds, the earth, or the "return stroke," or the whole combined. Mr. Mott says "points are of vital importance before the instant of discharge arrives," and he might add, of no account when they occur.

"An improper termination of a lightning-rod is to connect it with the gas or water pipes of a city or village beneath the surface of the earth. Theoretically, it is the best possible termination; practically, one of the very worst," &c.

Mr. Mott may connect a rod to earth in his way, and throw in any desired amount of charcoal. I will connect the same rod to a gas or water pipe, and then apply a current to the rod, and demonstrate that this current goes to the pipes in at least the proportion of a thousand to one.

The author, further on, refers to Mr. Crosse's experiments, whereby he discharged fifty Leyden jars twenty times a minute, accompanied by reports as loud as those of a cannon." This experiment was probably performed about the time the Dictator was struck, "during fine weather and a clear sky."

I will only remark, in conclusion, that it would have been more satisfactory had the author adopted the phraseology of many parts of my paper without interpolations.

Yours truly, DAVID BROOKS.

Bibliographical Notices.

A Treatise on the Construction and Operation of Wood-Working Machines, including a History of the Origin and Progress and Manufacture of Wood-Working Machinery. By F. RICHARDS, Mechanical Engineer.

We can fully endorse the following very flattering opinion of the work in question, which is expressed by our esteemed contemporary, "Engineering":

With the exception of a very few imperfect articles in Encyclopædias, two or three papers read before scientific societies, and the description of special machines contained in patent specifications and in the pages of technical journals, such as our own, the subject has been left untouched; and until the appearance of the book now before us, there was, so far as we are aware, none that could be referred to for information as to how wood-machines should be constructed and managed. Under these circumstances, Mr. Richards' Treatise is doubly welcome; it is welcome in the first place because it supplies a want, and in the next place because it supplies it well. . . . . Mr. Richards devotes two sections of his work to a consideration of wood-working machinery generally, and to an explanation of the principles that govern wood-cutting; these explanations being accompanied by data concerning hand-power operations and the performance of the same work by machines. . . . It contains information that will be appreciated by a large circle of readers besides those specially interested in the construction of wood-working machinery.

Civil and Mechanical Engineering.

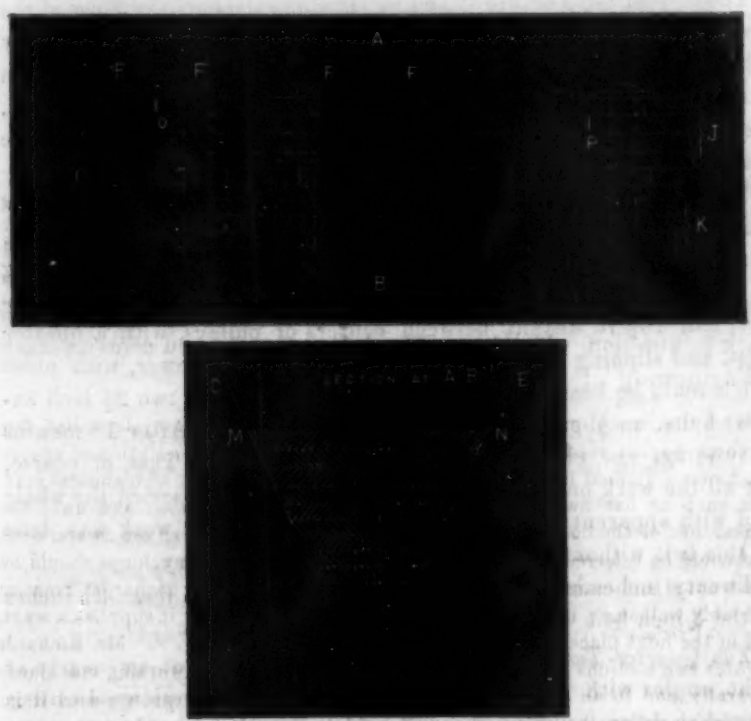
BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from Vol. LXV, page 327.)

Underwood's Patent Angular Belting.—This driving belt consists of a number of narrow leather bands, laid a-top of one another, lapping and breaking the joints in order to secure the greatest combined strength.

To the under side of this compound band are fastened short piles of leather, of equal length, forming blocks, each secured to the band by two iron rivets, as shown in this sketch:



The four bands, J, are continuous, the five pieces, K, and shorter pieces, I, interposing, are held together by the rivets, F; all are

shaped to the angle C D E, which is the correct angle of grooves for the wheels.

The length of the blocks is made as short as construction will permit, in order to increase the surface of contact while bending in the groove of the wheels; the pieces I are made shorter to give more flexibility to the band, for which also the blocks are separated by a narrow space.

The elasticity of the leather is sufficient to allow of the necessary bending of the four united bands without injury to the fibre, as it is not intended to use this belt over pulleys of small diameter.

The four bands, J, thus constituting the "wrapping connector" and tensional strength of this system, while the blocks K form the frictional wedges, so to speak, and the sloping edges of all in the angle of the groove contribute to the great adhesive power possessed by this driving belt.

The ends of this belt are joined by bevelling the opposite faces of the part J for 18 or 20 inches of its length, and then uniting the whole by bolts having washers and nuts at F, and with heads inside, similar in size and position to the rivets; or the separated strands may be joined, the top one say at O, the next one at P, and in no case having more than one joint between any pair of rivets.

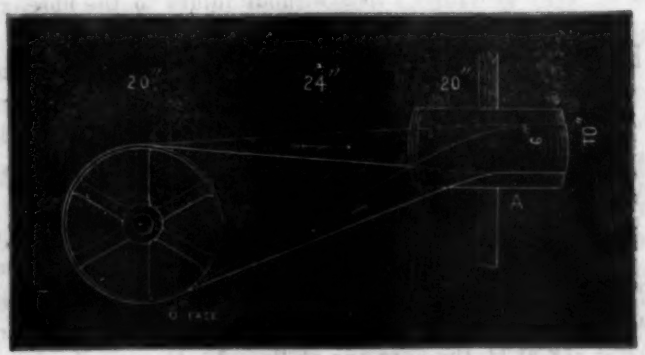
We have a practical illustration of the driving capacity of this kind of belt in the N. H. and N. Y. Railroad shops, at New Haven, Conn., where a 22-inch double leather belt of Hoyt's make, weighing 2½ lbs. per square foot, running on pulleys of 6 ft. and 4 ft. diameter, and 16½ ft. distant between centers of pulleys, with a quarter twist, and slipping under a load of 75 to 80 horse-power, with noise which could be heard 1¼ mile away, was replaced by two 2½ inch angular belts, on V-grooved wheels of same diameter. After 16 months of running, one of the angle belts was removed. This, of course, put all the work on the remaining one, and this one carried the whole load with apparent ease. Afterwards one-third more work was done by this belt without slipping, visible straining or injury.

Twenty inches length of the 2½-inch belt weighs 2 lbs. 21 inches of the 3-inch belt weighs 3 lbs. M N is the breadth.

The Quarter-Twist Belt.—When two shafts are at or nearly at right angles with each other, and not in the same plane, and it is desired to drive one from the other by two pulleys only and a connecting belt, experience has proved that certain conditions are necessary. In the first place, the distance between the near faces of the

pulleys must not be less than four times the width of the belt. The pulleys A and B should be so placed that the belt will lead from the face of one to the center of the face of the other, that is, so that *a plane passing through the center of the face of one pulley will be tangent to that part of the face of the other from which the belt is running.*

The following diagram gives the position and proper proportions referred to:



The pulley A, from which the belt deflects, should have a wide face than B, in the proportion of 10 to 6, and should be more rounding on the face than is usual, and the pulleys should be as small as may be to do the work, and should be of nearly equal size.

The superintendent of Cedar Point Iron Company, Port Henry, N. Y., says, in reference to the comparative merits of steel and iron wire ropes for hoisting purposes:

"We have used iron and steel wire ropes extensively at our iron ore mines, and our experience in hoisting from 1000 to 1500 tons gross per day awards the superiority by all odds to steel. One steel rope lasts us, on an average, as long as six iron ones.

"We attempted to run them on same sheaves as we had used for iron ropes, and found in some cases that the steel rope would cut one inch into the cast-iron sheaves in one or two months of use.

"Our sheaves now are lined with wood, which entirely obviates every difficulty in the use of steel, and of course is equally to be commended for iron." Jan., 1873.

Rule for New Length of Belt when Size of Pulley is Changed.—Take three times half the difference between the diameters of the

pulleys, and the result will be the length of belt to take out or put in. For instance, if you wish to change from a 16-inch to a 20-inch pulley, the difference is 4 inches; then $\frac{3 \times 4}{2} = 6 =$ the length of belt required.

In case the belt wanted tightening before, make the necessary allowance on the piece.—J. B. DOOLITTLE, *Sci. Amer., Jan. 25th*, 1873.

AN ELEMENTARY TREATMENT OF ZEUNER'S SLIDE-VALVE-DIAGRAM.

BY HUGO BILGRAM.

The popularization of science being one of the objects of this Institute, it will, perhaps, not be amiss to bring before you in a new and purely elementary form a rather old subject, the Slide-valve-diagram.

One of the most important parts of the steam-engine is the Steam-Distribution-Valve. The slide-valve, moved by an excentric, as invented by James Watt, with its modifications, has so many advantages above any other form of distribution-valve, on account of its simplicity, durability and limited dimensions, that almost every competition was decided in its favor. But, although it was in use since more than a century, yet its action and the relation which the dimensions and the positions of the different acting parts bear to each other and to the resulting steam-distribution has been thoroughly studied only about 25 years ago. Because the algebraic equations which represent the action of the valve are of a complicated character, some distinguished professors have devised the construction of geometrical diagrams, which are a clear and comprehensive representation of the process of steam-distribution by the slide-valve. These great and valuable attainments, however, are accessible only to such persons which had the opportunity to study the higher branches of mathematics, as these diagrams have been obtained by their aid, and for this reason they are less frequently applied than their merits admit. Persons who in defiance of this difficulty desire to make use of these elaborations of our great thinkers are obliged to commit to memory more or less complicated rules without having any conception of their whys and wherefores. It is quite natural that under such conditions even comparatively simple rules appear complicated and are apt to be

forgotten or confounded. An attempt to give an elementary explanation of one of these diagrams may therefore be justified, and if successfully accomplished may be valuable to designers, and even to mechanics engaged in the manufacture of steam engines, and to engine-tenders. The diagram to be explained is that devised by Prof. Zeuner, which, in most respects, is preferable to any other diagram constructed for this purpose.

The following considerations relate to horizontal engines of the usual construction, or, to speak more general, to such engines in which the connecting-rod and the excentric rod operate in parallel directions. Other engines for which this condition is not fulfilled, for instance such with a beam, have to be compared to horizontal engines in the manner indicated further below.

I suppose I need not explain the construction of the slide-valve represented in Fig. 1. If this valve occupies its middle position, its face not only covers the two steam-ports, but it overlaps them, *a b* being the outer and *c d* the inner lap. To facilitate the explanations we may term "positive" a motion to the right, and a reverse motion "negative." The port at the right-hand side will be in connection with the exhaust-canal when the distance of the valve from its middle position surpasses the extension of the inner lap, while the other port will be open for admission of full steam only after this distance is greater than the outer lap. If at any time the deviation of the valve is known, the width of the formed aperture for either admission or exit of steam can easily be determined by subtracting the respective lap from this deviation. Only after the port is completely uncovered, a continuation of the motion of the valve can no more increase the section of the opening, which obviously never can exceed the width of the port. Such a surplus of deviation only tends to lengthen the time during which the steam can pass through the port without any hindrance.

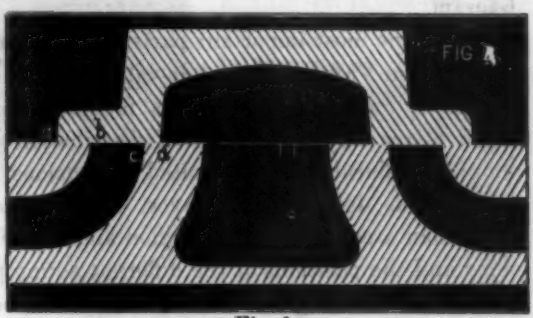
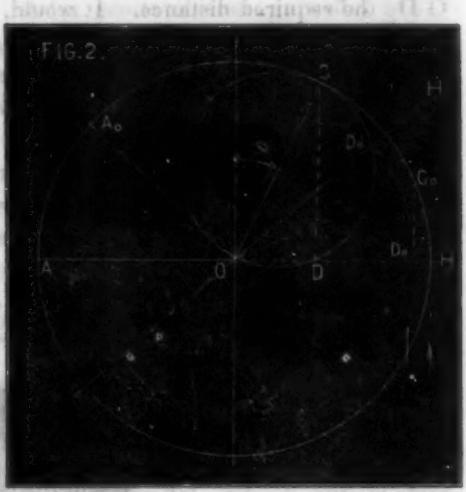


Fig. 1.

The object of our next pursuit is to find the deviation of the valve

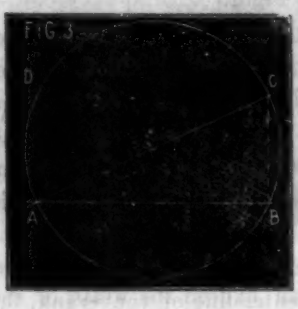
for any given position of the piston, or of the main shaft, by a simple method.

The excentric, which has the purpose of moving the valve, acts like a crank whose length is equal to the excentricity, and it is keyed to the main shaft, forming an obtuse angle with the main-crank. In Figure 2, O represents the centre of the main shaft, OA the direction of the main-crank and C the centre of the excentric disc. (The scale of Figs. 2, 4 and 5 is twice as large as that of Fig. 1).



The length of the excentric-rod is from 20 to 30 times greater than the excentricity, and therefore its oscillatory movement is limited to a very small angle, and the shortening of the horizontal extension of the rod, on account of this oscillation, may be neglected. Hence the deviation of the valve from its neutral position is equal at any time to the distance of the centre of the disc from the vertical axis.

Before proceeding any further I desire to elucidate a geometrical proposition, which will be necessary for the deduction of the theory of the diagram. If A B, Fig.3, is a horizontal line intersecting the circle A B C D in A and B, and if A C is a diameter of the same circle, which is a line going through its center, then C is vertically above B. Geometry furnishes the proof by the known proposition that the angle in the semicircle is a right one.



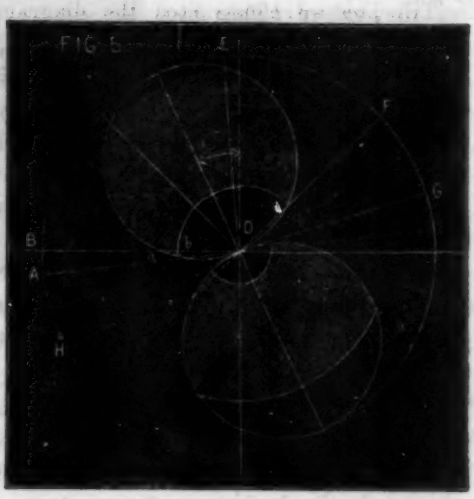
Returning to Fig. 2, it follows that if a circle is drawn, the diameter of which is the line O C, which represents the excentricity, it will always intersect the horizontal axis OH in a point, D, which is the horizontal projection of the center, C′, no matter whatever

position the shaft may occupy, and its distance from O is equal to the deviation of the valve. If the whole diagram except the horizontal axis is rotated in the same direction in which the main shaft of the engine rotates, this point of intersection imitates perfectly the motion of the slide-valve. To find the relative position of the valve for any given angle of the crank, we need only turn the diagram till O A_0 occupies this position, and we have in the chord O D_0 the required distance. It would, however, on a drawing-board be very tedious to revolve the whole diagram, and to draw it in different positions while the horizontal line remains stationary. But we attain the same results when, instead of turning the diagram in the positive direction, we turn line O H in the opposite or negative one, through the same angle. We can leave the main characters of the diagram stationary, and need rotate only one line on the center of the diagram. But it is inconvenient to have this motion proceeding in the opposite direction to that of the crank. Nothing is easier, however, than to overcome, also, this difficulty, by simply inverting the diagram, and reproduce it as shown in Fig. 4. For the given angle of the crank, O A_0, we had, according to the first form of the diagram, O D_0 (Fig. 2); in the second O D'^0, and in the third form O D (Fig. 4), representing the deviation of the valve. This last diagram is that at which Prof. Zeuner arrived by profound calculations. A line drawn through the center, O, at the angle of the crank, gives instantly the corresponding deviation of the valve, by the length of the chord formed in the valve circle. If this chord is cut out of the negative prolongation of the center-line of the crank, for instance, when the crank is at O A'_0, then is the deviation of the valve negative. As it were, the two ports changed their functions, and the piston moves in the opposite direction under the same conditions. From this it appears that for directly opposite positions of the crank, the deviations of the valve are equal but reversed.

The excess over 90° of the angle formed in horizontal engines between the excentric and the crank is called the angular advance, and can, by the following proceeding, easily be determined for any engine. Set the main shaft until the excentric is at a right angle, or, what is the same, until the slide-valve is in the middle of its stroke, and mark the position. Then turn in the positive direction till the crank arrives at its dead point. The angle of this motion is the required angular advance. The diagram should in any case be constructed as though it was intended for a horizontal engine with an equal angular advance, in order to obtain for all engines such diagrams whose general characteristics are uniform.

Since we can by this method find the position of the valve for any angle of the crank, we can easily find the widths of the openings formed for the passage of steam, by drawing two circles whose radii equal the outer and the inner lap. By their aid we can at once subtract from the diverse deviations the respective laps. So is, for instance, for the crank position O A the deviation equal to O *a*, and therefore the port for admitted steam is open as far as *a b*, and that for exhaust as far as *a c*. The outer circles have a respective distance from the two lap-circles equal to the width of the ports, and indicate the angle of motion during which the ports are fully opened, but they are evidently of inferior importance.

To separate the action of admission and of the exhaust of steam, it is advisable to draw a second circle opposite to the first one, as shown in Fig. 5, and to devote one to the admission and the other to the exhaust of steam. This measure can be justified, because the deviations are equal for opposite positions of the crank, but more so, because the same port which will be opened for admission by a positive deviation, will be opened for exhaust when the deviation is negative, and *vice versa*. Following by the diagram the distribution of steam for one side of the cylinder, or for one port, we find that at the posi-



tion O A the rotating radius enters into the upper figure which represents the admission of steam, the inner circle having a radius equal to the outer lap. This indicates that at this position of the crank the admission of steam will commence, for the deviation, the chord in the valve-circle, is now equal to the outer lap, as the radius of the lap-circle. When the crank reaches the dead point, B, the port will be opened to an extent equal to *a b*, which is called the lead. Angle A O B is called the lead angle. As the rotation of the main-shaft continues, the width of the formed opening for admission of steam will increase successively till at D the port is fully opened, as its distance from its neutral position equals the sum of the outer lap and the port width. From this time to the time it passes the radius O E the deviation of the valve is greater than necessary to open the port entirely. When the crank arrives at F the radius leaves the upper figure of the diagram. Hence the admission of steam will be interrupted and expansion will commence, and last till the rotating radius enters the lower figure (designated for exhaust, as the radius of the inner circle equals the inner lap) which takes place at G. From there till to the exit of the radius from this figure, at H, the considered side of the cylinder is connected with the exhaust-canal. The steam which after the cut-off of the exhaust at H is retained in the cylinder, will be compressed until at A the port is again open for the admission of full steam to start the next stroke. The action on the other side of the piston is similar, and may be examined by following the same course with the negative prolongation of the crank.

Till now we constructed the diagram when the excentricity, the angular advance and the laps were given, and inquired for lead, lead-angle, cut-off-angle and steam-compression. But after knowing the features of the diagram, it can equally well be constructed when excentricity, lead-angle, cut-off-angle and the beginning of compression are given, and the diagram will answer our inquiries on angular advance and inner and outer lap, and thus will be adapted for the construction of new engines.

It is, however, not my intention to explain here all the possible applications of this diagram, as the time is entirely too limited, but the said may suffice to show the logic of the diagram and the manner in which it may be used.

Professor Zeuner used this diagram by the aid of high mathematics for the investigation and construction of the more complicated valve-motions, for the different link-motions and for Meyer's valve with

adjustable cut-off plates. The same diagram may also be used in an elementary way for the attainment of the same purpose.

I hope that this new deduction of the theory of the diagram may tend to make the use of this geometrical method more popular among the engine-builders.

BRIDGE-BUILDING CONSIDERED NORMALLY.

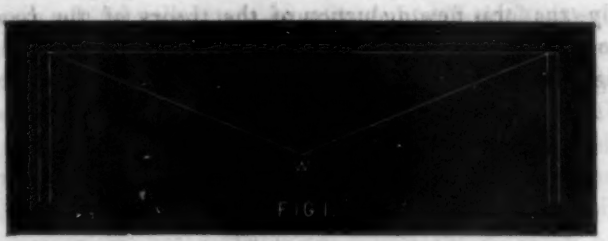
By John W. Murphy.

Darwin says we are a race that has descended from a long line of magnificent Apes. Whether I agree with Darwin or not will make no difference in the subject I propose to discuss. I know that the first bridge-builders that were of kin to humanity were the monkey race. Travellers who have been through the wilds of Africa, South America and portions of India tell us how the monkey is a bridge-builder. The traveller has frequently described how he has seen a convoy of monkeys making the attempt to cross a stream, and succeeding by a process which he describes in this wise: The leading monkey climbs a tree as close to the shore as he can make choice of, holding by his forearms to the limb of the tree. He gives opportunity to each succeeding monkey to entwine himself with his prehensile tail, until one after the other they have become so attached, head and tail (the height of the tree being equal to the width of the stream); that the lower monkey, starting forward from the ground, by a pendulum movement swings himself to the opposite side of the stream. He then climbs the nearest tree, and when he has gained the height of the first monkey it will be easy to understand that there will be formed a catenary curve of monkeys from tree to tree across the stream. On this curve the youthful monkeys, the comparatively infantile monkeys and the aged monkeys cross over in perfect safety, and no monkey, either youthful, infantile or aged, wets his feet in the water in crossing.

Now let us see how our catenary bridge is removed when its work is done. The first monkey, by a signal from the other side of the stream, lets go his hold of the limb and swings gracefully to the other side. Now, if Darwin be correct and we *are* descendants of a race of monkeys, then it must be truthfully said that our ancestors have given us the best thoughts and principles of bridge construction.

There is no doubt that the suspension curve, where the material acts by tension, is the most *economic* form, the *safest* form, and the

most *artistic* form for the support of moving or stationary bodies over space.



The Peruvian, with his grass ropes, throws across the gorges of the Andes a primitive bridge, which is no more nor less than the monkey bridge just described, with this difference, that the monkey uses his own *body* to make the chain, while the *Peruvian* uses long grass from the Pampas. Another difference is that the monkey uses but one rope or cable, while the Peruvian uses two. See how easy it is to do as the Peruvian does. We have only to take the material at our hands, make a chain, connect it from point to point, from shore to shore, put some plank upon the two cables that lie side by side, at at any practicable distance apart, and we can make a bridge that we can walk over, if we descend from the summit of the abutment down to the bottom of the deflection of the catenary curve of our rope.

It is plain that, if our ropes are reliable, we can erect staunchions upon them at practicable distances apart, and that we can manage and truss these staunchions so that we may be enabled to construct a roadway on a horizontal line, notwithstanding that this roadway is dependent upon the catenary curve that bellies below it.

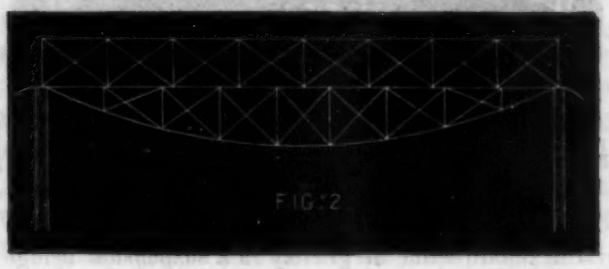
Our ancestors (according to Darwin) have therefore given us a magnificent thought. Charles Ellett and John A. Roebling have copied this principle in their great forms of construction, such as the bridge at Niagara Falls, the largest span for railroad purposes in the world —810 feet from shore to shore; the bridge at Cincinnati, the central span of 1110 feet, with two co-ordinate spans of 500 feet each; also the bridge at Fairmount, 342 feet span, designed by Charles Ellett, the first suspension bridge built in the United States.

If I could cast aside all the prejudices of the engineering fraternity regarding bridges, I would build them on the same principle that the monkey builds his.

I am free to say that Whipple, Linville and Murphy are all wrong in the principles they evolve in the construction of bridges. While

their works show skill and aptitude in the sustainance of bodies moving and stationary over space, I declare that the suspension form is the only *true* form for *any* structure that relies for the conserver of weights that are carried or impinged upon it.

In 1853 I erected a bridge across the Delaware river at Easton, Pa. It was obligatory by my contract that I should execute this work during the spring and summer months. I found that the rafts that came floating down the river made it impossible for me to erect this bridge in the ordinary manner, that is to say, by placing trestles or false works in the stream, upon which the superstructure would ordinarily be erected. I therefore devised the following plan:



I took some wire ropes and suspended them from pier to pier, and placed staunchions upon them, braced them in the manner which will be understood from the drawing, and made a temporary bridge, upon which I erected the main superstructure.

I never will forget the pleasure it afforded me, in the erection of this work, to see the rafts passing freely underneath, and the feeling of security that I had in devising a plan by which I was enabled to erect this bridge without danger to myself, to my men, or to the raftsmen, who were obliged to float upon the high currents of the Delaware, and of course liable to injury to themselves or to my workmen.

Bridge construction, it seems to me, must ultimately come to the natural suspension curve. It is a natural curve. It is as though we were to take a rope or cable and swing it across the space to be spanned. If we examine into the lines of the curve formed by this cable when stretched across such space, we will discover that it hangs in obeyance to the law provided by lines resolved into three forms:

First. Resistance to gravity.

Second. The diagonal value due to that resistance over space.

Third. The horizontal component of these two values, which make the elements of stable equilibrium.

To take this principle and construct mechanically a stable and comparatively permanent structure, demands that we should understand most thoroughly the value of three nodal points of the curve.

I have said that there is one positive line, resistance to which must be provided against, and that is the line in the direction of gravity. The other is the diagonal, which is represented by the curve of our cable.

Material in the direction of gravity in a suspension bridge will be represented by the suspenders that hang from the cable, they supporting the roadway. The one representing diagonal and the other vertical forces, it follows that we have but one force to provide for, viz., the horizontal.

Material proportionate to the value of the strains in the direction of the three forces named must be employed.

Strains upon a suspension bridge are widely different from the strains upon rectangular forms of trusses.

A body supported over space by two lines acting by tension, requires no lateral bracing to hold it in equilibrium from side swinging, provided that care is taken that the width of the bridge at the towers is greater than the width at the centre of the roadway.

The suspension bridge at Fairmount is illustrative of this resistance to side motion; it having, if I remember right, some fifteen feet greater width between cables at the top of the towers than at the centre of the bridge.

The suspension bridge at Fairmount has no lateral bracing in it, and relies for its resistance to a side swinging motion, to the splay of the cables at the towers, and the compression or tightening of the curve at the centre of the bridge.

If we use the suspension principle in contradistinction to the direct arch, and all the rectangular systems of truss framing, we have at least *one* advantage, that the lateral bracing, both at top and bottom, may in a great degree be dispensed with.

Fig. 4.

When I have turned my suspension bridge upside down, it requires a new order of material to hold in line this arch.

The rectangular truss, in all its forms, involves material acting by thrust, and any form of construction which shall dispense with material acting by thrust is the best form, for this reason, material acting by tension depends for its value only upon the section.

Material acting by thrust depends for its value not only upon the the section but it also depends upon the diameter, if it be a column of any form that may be devised. A No. 10 wire of 10,000 feet long, if sustained in a horizontal line, will maintain a strain, acting by tension, of 1400 pounds; while the same wire, acting by compression, will not sustain a single pound.

In all rectangular forms of bridge construction thrust values exist. The top chord must be kept in line, to resist horizontal strain, in two ways:

First. In and of itself.

Second. By lateral bracing, in order that it maintain itself like a pillar or column.

It follows that when that form of construction that demands the majority of its parts to act by thrust, as is the case of the rectangular bridge, that there are faulty principles in the construction of bridges, *per se.*

In order that material shall resist a thrust strain, it is necessary that three conditions shall be fulfilled:

First. Quantity of material; in other words, cross section.

Second. Diameter; and

Third. That the length of the section shall have some definite relation to the diameter, and the quantity of the material in the cross section thereof.

Now, since parts acting by thrust must have a value equal to the cube of their diameters, directly and inversely as the square of their lengths, it follows that, in all rectangular forms of bridge construction, when that form of construction that demands the majority of its parts shall act by thrust, as is the case of the rectangular bridge —it follows that there are faulty principles in the construction of bridges *per se*.

That form of structure that shall best sustain, support and maintain bodies moving or stationary over space, should be such an one as will have the least amount of material acting by thrust.

If we examine any of the suspension forms, we will find that the primary condition is the hitching fast of a cable into the ground, the anchorage of which serves the part of our horizontal strains.

By making fast our cable into the solid masonry and into the earth itself, we do away in the suspension bridge with all horizontal values except those that are due to vibration.

The objection heretofore existing against suspension forms has been that under variable loads they undulate.

It has been found that where long spans have been constructed, from the great weight of the superstructure, bodies of lighter weight than the superstructure, have produced no undulations destructive or injurious to the superstructure.

Fig. 5.

A bridge can be constructed on the suspension principle that shall fulfil all the conditions of stability, freedom from vibrations, and absolute integrity as to strength.

It is not necessary, in the practical construction of a bridge based upon a suspension principle, to consider the suspension curve that of the catenary; indeed, it is better to consider the curve as consisting of a series of straight lines from nodal point to nodal point, in fact, a funicular polygon, of as many sides as there are points to be supported.

Fig. 6.

Suppose, for the sake of illustration, that we begin with a bridge that shall have but one weight suspended over space; the

Fig. 7.

weight, W, to be suspended by two chord lines from A to B. Suppose, again, that we have the same chord line supporting two weights, W and W′, dividing the space into what we would call three

Fig. 8.

panels. We might go forward practically and divide the space between our abutments, as will be seen, into a large number of panels. If we do, the greater the number of panels the greater will be the number of nodal points, and the greater the number of *nodal points* the more

closely will our suspension line approximate to the curve of the true catenary.

In the determination of what is requisite for the support of moving loads, it must be understood that if these loads are to be sustained *upon* a flexible cable or chain, or suspended *from* a flexible cable or chain, material must be used which shall act in the direction of tension.

The motive of this paper being to show that the suspension bridge, in any form that it can be constructed, demands *less* material in the lines of thrust strains than any other form, it will be our business to examine how *much* of the suspension bridge acts by thrust.

It will be plainly seen that the main supporting part of a suspension bridge is the cable or chain acting by tension, and that all parts that are to be supplied to resist undulations must act by thrust.

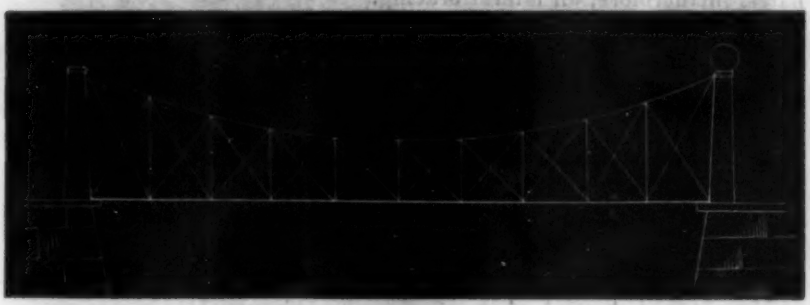


Fig. 9.

Suppose, in the above diagram (Fig. 8), that weights are supported on three nodal points, and that one of these weights is greater than either of the other two; it will be clear that our suspension cable will deflect in the direction of the greater weight and rise in the direction of the lesser weight. It is plain that the nodal points must be placed in equilibrium by material in the direction of a line forming the side of a triangle, which shall satisfy the conditions of equilibrium.

Now, suppose *this* case: a bridge divided into *three* panels (Fig. 8), weights hung upon a chord essentially at *two* nodal points. It is easy to see how we can fasten a chord line from a nodal point on the right to the abutment, and the nodal point to the *left* to the abutment, and thus secure an absolute stability and equilibrium of the nodal points at which places the weights act.

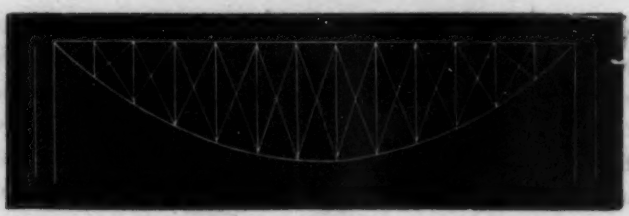


Fig. 10.

If we increase the number of panels, and consequently the number of nodal points, we will not change the principle that I have already demonstrated.

The suspension curve is the natural form for the construction of *any* bridge. It is that form, when placed mechanically exact, gives to us the very *purity* of theoretic bridge-building. It eliminates horizontal values if the cables be hitched on shore. The principle eliminates, furthermore, all lateral bracing.

Out of the three forces that we are to provide material against—the vertical, the horizontal and the diagonal—the suspension principle eliminates most easily the horizontal value, by means of the anchorage at each shore end of the work. The vertical value represented by the little threads that hang the roadway to the cable.

In truth, the suspension principle leaves us the necessity for only the diagonal value for the sustainment of bodies over space, and that is the cable itself.

In a future paper I propose to discuss the mathematics of the forms which I have described.

SOMETHING NEW CONCERNING THE PHYSICAL PROPERTIES OF STEAM.

By John Lowe, First Assistant Engineer U. S. N.

The volume, temperature, pressure, etc., of steam mutually depend the one upon the other, and vary simultaneously with each other. For example: the volume of one temperature and pressure cannot have the temperature and pressure of another volume; but these relations are strictly defined and are unchangeable.

These relations are well known, and may be found tabulated in Isherwood's works with critical exactness.

They are also expressed in the formula $\frac{Vp}{V'p'} = \frac{1+(t-39).0025}{1+(t'-39).0025}$ equation (1). In which V = volume of steam, (t) its temperature, (p) its pressure.

In the following table, column D contains the volume of steam as found in Isherwood's works, with the corresponding temperatures, pressures, etc., in the other columns, while column E contains the volumes as calculated by equation (1). By comparing the columns D and E, it will be seen that the formula is only approximate, but for our present purposes it is sufficient, although it is to be hoped that the co-efficients will be corrected at some future time.

Absolute pressures per square inch.	Temperature, Fahr.	Thermal units in one lb by weight of steam.	Relative volume of steam, water at 39° being unity. Isherwood.	Relative volume of steam calculated from equation (1)	Internal plus the external work of one lb weight of steam calculated from equation (2).	External work calculated from the equation No. (2).	Differences between temperatures 101·36 and t'.	Newly discovered constant derived from columns G and H.
A	B	C	D	E	F	G	H	I
1	101·36	1112·85	17983·2					
10	193·20	1140·86	2373·	2178·8	21624	795·55	91·84	8·662
20	227·50	1151 46	1219·7	1157·2	29700	1099·0	126·14	8·712
30	250·26	1158·26	826·327	801·36	35036	1296·3	148·90	8·706
40	267·17	1163·42	627·903	617·49	39031	1444·6	165·81	8·706
50	280·89	1167·61	508·292	504·93	42265	1565·0	179·53	8·711
60	292·58	1171·17	428·318	428·42	45024	1668·2	191·22	8·723
70	302·77	1174·28	371·076	372·94	47424	1758·5	201·41	8·730
80	311·86	1177·05	328·086	330·79	49564	1838·1	210·50	8·732
90	320·10	1179·57	294·610	297·64	51505	1906·3	218·74	8·715
100	327·63	1181·86	267·806	270·83	53277	1977·4	226·27	8·739

Let us put H as the total heat in steam. Now, if we compress steam from the pressure $p = 1$ to the pressures $p' = 10 = 20$, etc., as in the table, it has heretofore been supposed that a total work of $(H' - H)\ 772$ foot lbs must be performed. $(H' - H)\ 772$ is equation (2). See column F. This work is divided into internal and external.

We will not now attempt to define internal work; but external work may be defined as that which is exerted, for example, upon the piston of a steam-engine. The formula commonly used by the engineering profession to calculate external work is $E = V\ p\ l\left(\frac{p'}{p}\right)$, equation (3). In which $l\left(\frac{p'}{p}\right)$ signifies the Naperian Logarithm of $\left(\frac{p'}{p}\right)$ and E = the work restored by steam during expansion or stored in

compression. This formula possesses the merit of simplicity, and for ordinary purposes perhaps is all sufficient. But since the amount of work stored in compression equals the amount restored in expansion, if we accept this formula as correct we must say $E = V\,p\,l\left(\frac{p'}{p}\right) = V'\,p'\,l\left(\frac{p'}{p}\right)$, which is absurd by simple inspection. It will be observed that in this formula there is no consideration of temperature. The introduction of this element makes the formula correct, and

$$E = \left[V\,p\,\frac{1 + (t' - 39°).0025}{1 + (t - 39°).0025}\right] l\left(\frac{p'}{p}\right) =$$

$$V'\,p'\left[\frac{1 + (t - 39).0025}{1 + (t' - 39).0025}\right] l\left(\frac{p'}{p}\right) \text{ Equation (4).}$$

By this formula column (G) was calculated, and it is believed an important fact discovered, viz: *That the external work given out by steam in expanding from the temperature* (t') *to the temperature* (t), *bears a constant ratio to that difference, that is, to* (*t'—t*).

Column (H) contains these differences between $t = 101.36$ and $t' = 198 = 227$, etc.

Column (I) contains the constant ratio $\frac{E}{t' - t} = 8.7$, etc. This constant it is believed is now for the first time announced.

This constant is, it will be observed, almost a perfect one, the small differences arising from the imperfections of Equation (1). Because at 60 lbs. pressure the observed and calculated volumes coincide, this constant will eventually be put as 8.723.

We have then discovered a new formula for finding the external work, viz: $E = \gamma\,(t' - t)\,8.723$. Equation (5). In which $\gamma =$ the weight in pounds of steam.

This formula is a rigid one, since as before said, the pressure, volume and other properties of steam vary simultaneously. It expresses all the work that can possibly be obtained from steam by the steam engine.

The difference therefore between this formula and the work actually obtained will be the losses from condensation, etc. These losses will be found to be smaller than generally supposed. As before said, it has heretofore been supposed that the work that should be realized from the steam was $W = (H' - H)\,772$ foot lbs. But the reasoning of this article if sound proves that only

$$\frac{\gamma\,(H'—H)\,772}{\gamma\,(t'—t)\,8.723} = \frac{\gamma\,.305\,(t'—t)\,772}{\gamma\,(t'—t)\,8.723} = 26.9, \text{ or that}$$

only $\frac{1}{27}$th part of the total heat can possibly be realized theoretically.

This article is only preliminary; but the opinion of the writer at present is that the latent heat performs the internal work, while the sensible heat only is available for external work. If this is correct, then that vapor whose latent heat is the smallest, other things equal, would be the best agent for converting heat into work.

THE ICE-GORGE IN THE SCHUYLKILL ABOVE FAIRMOUNT.

By John W. Murphy.

A paper read before the Franklin Institute.

The ice-gorge in the Schuylkill, at Turtle Rock, extending backwards up the stream some seven miles in distance, has attracted a good deal of attention.

The fear of the effect of the sudden disgorge of this enormous mass of ice has given grave apprehension to the citizens of Philadelphia.

The Fairmount Dam is in danger. If it gives way, damage and destruction follows. Market street, Chestnut street and the partially completed South street bridges will be swept out of existence.

There is nothing, therefore, that engineering skill can or has devised that can withstand this terrific gorge if once in motion.

Think for a moment of a field of ice some miles long, seven hundred feet wide and twenty feet deep, moved by a freshet such as would send it crashing its way against every obstruction that impeded its progress!

Now the purpose of this paper is to show that this gorge of ice is in fact the protection to all structures below it.

Ice is gorged under two conditions of the stream; the first condition is when the stream is rising, the other is when the water falls. Persons who are accustomed to look upon the breaking up of ice in the river, and seeing masses of ice moved by a freshet, rarely comprehend the difference between an ice-gorge that may last for a moment, for an hour or for two hours, and then break away by force of a continually rising current, and a gorge of ice that has been stranded upon the bottom of a river, where the freshet runs away from it, and leaves it high and dry.

In the latter case, the first portion of the ice-floe is stopped, and jammed against the shores. The water running from underneath it allows it to sink to the bottom. The ice following after accumulates behind, piling in upon the stranded obstruction in front. The subsidiary water fails in strength to move forward the obstruction and only gives opportunity to make the barrier stronger.

An observation of the ice-gorge above the dam at Fairmount shows us that each cake of ice has been set down to the bottom of the river edgewise. As evidence of it, any one who will glance at the surface of it will see that every stick of wood, débris and logs and all light floating material stand upright, as though an engineering party had been driving stakes to make a topographical survey of the territory.

A gorge of ice is always an evidence of a falling stream, in fact it may almost be said a season of drought (low water).

Consequently, before a gorge can be raised, and moved to be destructive to structures below it, there must be a volume of water poured into the stream at least three times greater than the initial freshet that caused the gorge.

If ice weighs 58 pounds and water 62½ pounds to the cubic foot, it will be clear that the difference in flotation will be as 58 is to 62½; in other words, one-sixth in round numbers will be out of water and five-sixths will be submerged.

Now, where a freshet occurs and carries with it a mass of ice five-sixths of which is under water and one-sixth above, whatever be the thickness of the ice, it carries with it elements of great destruction; because the specific gravity of ice is so near to that of water, that when it has great thickness and velocity it acts against any obstruction like a projectile.

An ice-gorge and an ice freshet are widely different, for in the case of the ice freshet the horizontal mass, whatever may be its thickness, is raised from its normal condition and moved forward by the flood.

Referring, then, to our thought, that five-sixths of the ice is below the surface of the water, and, if it be in a condition of flotation, it will require a freshet of 16 feet, measured on the dam at Fairmount, to move the gorge bodily.

I therefore conclude that no danger may be apprehended below any gorge similarly situated as the one above the dam at Fairmount.

Chemistry, Physics, Technology, etc.

STATISTICS OF COAL.

Compiled from the "Coal-Regions of America; their topography, geology, and development. With a colored geological map of Pennsylvania, a railroad map of all the coal-regions, and numerous other maps and illustrations. By James MacFarlane, A.M."

I. IN FOREIGN COUNTRIES.

A comparison of our trade with that of our neighbors is always instructive. The largest production of coal in the world is that of Great Britain, which is more than three times that of the United States, and more than all other countries in Europe together. A brief account of it may be useful, now that it is supposed to have attained its maximum, while ours has scarcely passed its infancy.

The following are the official statistics of the coal mined in the United Kingdom of Great Britain:

Years.	Tons mined.	Annual Increase.	Annual Decrease.	Home Consumpt'n.	Tons exported.
1854....	64,661,401	.....	.....	60,351,146	4,309,255
1855....	64,453,070	.....	208,322	59,476,168	4,976,902
1856....	66,645,450	2,192,371	.....	60,765,671	5,879,779
1857....	65,394,707	.....	1,250,743	58,656,959	6,737,718
1858....	65,008,649	.....	386,058	58,479,166	6,529,483
1859....	71,979,765	6,971,116	.....	64,972,816	7,006,949
1860....	84,042,698	6,062,933	.....	76,720,866	7,321,832
1861....	86,039,214	1,996,516	.....	78,184,099	7,855,115
1862....	81,638,338	.....	4,400,876	73,336,486	8,301,852
1863....	86,293,215	4,653,877	.....	78,017,003	8,275,212
1864....	92,787,873	6,495,658	.....	83,977,965	8,809,908
1865....	98,150,587	5,362,714	.....	88,980,110	9,170,477
1866....	101,630,544	3,479,957	.....	91,676,832	9,953,712
1867....	104,500,480	2,869,936	.....	94,084,702	10,415,778
1868....	103,141,157	.....	1,359,323	92,303,353	10,837,804
1869....	107,427,557	4,286,400	.....	96,839,132	10,588,425
1870....	110,431,192	3,003,635	.....	99,926,920	11,504,272
1871....	117,352,028	6,920,936	.....	104,802,152	12,549,874
1872....	.....	.....	.....	.....	13,211,961

It is remarkable that there is no authentic account of the quantity of coal mined in Great Britain previous to the year 1854. The first report of the "Mineral Statistics in the United Kingdom," giving with all possible exactness the quantity of coal raised, as obtained by direct application to the coal-owners, was published in July, 1855, and annually since that period a similar detailed report has been issued. The following is an estimate, made from the best data obtainable, by Mr. Robert Hunt, the chief of the Mining Record Office,

of the United Kingdom, of all the coal mined in Great Britain since coal was first used in the country:

Mined in the three centuries before 1800	850,000,000
Mined from 1800 to 1853	2,000,000,000
Mined from 1854 to 1870	1,454,224,897
Total coal mined in Great Britain	4,304,224,897

The following are the uses made of the coal mined in 1869:

Used in iron manufactures	32,446,605
General manufacturing, steam-power, etc	25,327,213
Metallurgies, other than iron	859,231
Mines and collieries	7,225,423
Gas and water-works	7,811,980
Steamships	3,277,562
On railways	2,027,500
Domestic consumption	18,481,527
Miscellaneous	195,045
Exported	9,775,470
Total production in 1869	107,427,557

Among the notable points in the above statement are the very large proportion of the coal used in the manufacture of iron, thirty-two and a half million tons, and the small quantity used on railroads, being only two million tons. In looking forward to our probable future coal-trade, it is evident that our railroads will soon furnish a large, perhaps the largest item in the account of our consumption of coal, instead of one of the smallest, as in England. The use of wood in locomotive engines is only temporary. So large is the consumption of fuel in these machines, that our forests go down before them. On the New York Central Hudson River Railroad each engine consumes seven hundred and fifty tons of coal per annum. On roads with a lighter traffic a less quantity may be used, but it cannot be questioned that the consumption of coal in this manner will very soon amount to many million tons. The use of coal for domestic purposes in this country will very much exceed that of Great Britain in proportion to the population, owing both to the greater severity of the climate, and the more equal distribution of property, which enables our whole people to indulge in the free use of the best fuel. The manufacture of iron is vastly on the increase here, as well as manufacturing generally, both of which have been lately much stimulated by the increased price of coal, and cost of labor of all kinds, in England.

The exportation of coal is a branch of the trade which has scarcely begun in America, and which is destined at an early day to absorb millions of tons of our production. Our beautiful anthracite, the

finest domestic fuel in the world, only needs to be known and used, to become one of the luxuries which the wealthy abroad will require of Pennsylvania.

There is the same gradation in the coal-fields of Great Britain as in Pennsylvania. The type of perfection in gas-coal is the Scotch Cannel. The quantity of gas produced decreases constantly in going southward, through the Lancashire, Yorkshire, New Castle, and Staffordshire basins successively. Farther south than the last, the coals run through several varieties of semi-bituminous into the anthracite of South Wales and Ireland, and then into the worthless culm of Devonshire. It is estimated that there are in Great Britain seventy varieties of coal.

The most important and productive of the coal-fields of England is the Durham and Northumberland basin near Newcastle. It is 50 miles long, from six to 24 miles wide, and produces about 24 per cent. of the coal mined in England. In this basin are 16 seams of coal more than 18 inches thick, six of them being more than three feet, and ten of them less than three feet. The two most important beds, the High Main and the Low Main, are each of a thickness of six feet, with a layer of slate or poor coal in each. In England, six feet in thickness of coal is a good bed, and from one to two yards is a common size. This north-of-England region has been for a long time the principal source of the supply of English coal.

The Staffordshire and Worcestershire coal-field is 21 miles long, and its mean breadth is between seven and eight miles. The Dudley coal, in South Staffordshire, is of limited extent, but the principal bed of coal is 30 feet thick, and varies from 24 to 36 feet, which is a very extraordinary thickness; and there are five other good beds, measuring 4, 4, 8, 7, and 12 feet, the whole thickness of coal being 65 feet. Staffordshire and Worcestershire produce about 11 per cent. of the whole product of the United Kingdom. North Staffordshire, called the Potteries, has 40 seams of coal, with a total thickness of 140 feet of coal, of which 22 are large workable beds measuring in all 94 feet. Yorkshire has 16 seams of coal, with a total thickness of 45 feet, of which the best bed is five or six feet. Leicestershire has ten seams of a workable size, with 45 feet in all of coal. The Cumberland coal-field has three workable seams. Derbyshire produces the valuable splint-coal.

Scotland produces 13 per cent. of the coal of the United Kingdom. The great coal-field of Scotland has an extreme length of 94 miles, with an average breadth of 25 miles, and a workable surface of some-

where between 1,450 and 1,750 square miles. In Lanarkshire there are 20 to 30 beds of coal. Clyde has 84 coal-beds; Johnstone has 10 coal-beds—in all 100 feet of coal. The Midlothian has 24 seams, measuring 94 feet. East Lothian has 50 to 60 coal-beds, over one foot thick, in all 188 feet, the thickest being 18 feet. Kilmarnock produces anthracite. Basin No. 34, south of Ayrshire, has 51 feet of coal; and in the Clackman, in Fifeshire, there are 142 coal-seams. In North Wales the coal is bituminous; there are seven beds in all, from 27 to 30 feet thick, the largest being from six to seven feet. The coal-field of South Wales is 54 miles from east to west, and 18 miles in width. The coal-producing rocks are 10,000 feet thick, and a full section shows 25 workable seams above two feet thick, making in all 84 feet of workable coal. Ireland has about 70 collieries, of which 30 are working on old pillars on a small scale, only producing, in all, 165,750 tons in 1871. England, Scotland and Wales had 2,730 collieries in 1871. From the following statement it appears there is but little variation, from year to year, in the relative quantity of coal produced in the several districts:

Summary of the Quantities of Coal produced in each Coal District in the United Kingdom, as officially reported.

DISTRICTS.	1865.	1867.	1869.	Average for ten Years, 1860—1869.
Durham and Northumberland	25,033,000	24,867,000	25,765,000	22,741,000
Cumberland	1,431,000	1,513,000	1,411,000	1,269,000
Yorkshire	9,355,000	9,844,000	10,830,000	9,861,000
Derbyshire	4,596,000	4,551,000	5,460,000	5,756,000
Nottinghamshire	1,095,000	1,575,000	1,575,000	
Leicestershire	965,000	1,150,000	651,000	810,000
Warwickshire	889,000	881,000	586,000	704,000
Staffordshire and Worcestershire	12,201,000	12,527,000	12,669,000	10,374,000
Lancashire	11,965,000	12,841,000	13,996,000	12,047,000
Cheshire	880,000	935,000	957,000	856,000
Shropshire	1,135,000	1,558,000	1,393,000	1,181,000
Gloucester, Somerset and Devonshire	1,875,000	1,975,000	1,980,000	2,735,000
Monmouthshire	4,125,000	4,569,000	4,275,000	3,352,000
South Wales	7,912,000	9,092,000	9,180,000	7,808,000
North Wales	1,983,000	2,371,000	2,155,000	1,997,000
Scotland	12,650,000	14,126,000	14,417,000	12,508,000
Ireland	124,000	125,000	128,000	125,000
Total	98,151,000	104,500,000	107,428,000	93,925,000

In the year 1866 some degree of public anxiety was awakened in England on the subject of the permanence of their coal-supply. The scientific journals directed attention to the calculations of Prof. Jevons, and the matter was discussed in Parliament. In June of that year a royal commission was appointed to inquire into the several matters relating to coal in the United Kingdom. After five years of investigation at great expense, with the advantage of paid assistants, and with every facility afforded them for collecting materials, their report was completed in July, 1871, forming three large volumes, in all 1,250 double-column pages, royal quarto size.

"The subjects intrusted to the five committees were: the possible depth of working, waste in combustion, waste in working, the probability of finding coal under the Permian, New Red Sandstone, and other superincumbent strata, and mineral statistics respectively.

"The investigation to determine the maximum depth to which it would be possible to work coal has not been conclusive, but the commissioners consider, from the evidence before them, that it might fairly be assumed that a depth of at least 4,000 feet might be reached. This acknowledgment must give general satisfaction; for, at present, there are only about two mines that have reached one-half of that depth, and, from the experience gained in those, it appears that the high temperature is not in many cases permanent, and is frequently much modified by accidental circumstances. The temperature of the earth is constant at a depth of about 50 feet, and at that depth the temperature is 50° Fahr. The rate of increase in the coal districts is generally about 1° Fahr. for every 60 feet of depth. The heating process is most rapid at first, when the difference of temperature between the air and the strata is greatest, and gradually diminishes as the length of the passage is extended, never ceasing until complete assimilation of temperature. The air takes up the heat much more rapidly in pillar and stall working than in long-wall. The absorption of heat from the strata, by the circulation of the air, gradually lowers the temperature of a mine.

"The labors of Committee C were directed to the inquiry whether there is reason to believe that coal is wasted by bad working, or by carelessness. It seems that the extension of the long-wall system has diminished waste, but much is still lost by bad working and carelessness—a very considerable amount in proportion to that which is actually used. Under favorable systems of working, the loss is about

10 per cent., while, in a very large number of instances, the ordinary waste and loss amounts to 40 per cent.

"With regard to the quantity of coal in known coal-fields, it is estimated that within depths not exceeding 4,000 feet, and after making the necessary deductions, there are (including upward of 130,000,000 tons in Ireland) 90,207,285,398 statute tons; while below 4,000 feet there are 7,320,840,722 tons, making 97,528,126,120 tons in all, and, in the estimate, no consideration has been taken of any bed of coal less than one foot in thickness. To this must be added a further quantity of 56,273,000,000 tons for the probable amount of coal under Permian and other overlying formations at depths of less than 4,000 feet, and deducting 40 per cent. for contingencies, giving an aggregate of 146,480,000,000 tons. Estimating a gradual increase in the population, and that the consumption per head of population will attain its maximum at the end of the present century, a total consumption is shown of 146,730,000,000 tons in 360 years, so that about Christmas, 2231, we shall have to look for our supply of coal from the sub-Permian deposits, at a depth of below 4,000 feet. The commissioners admit that every hypothesis must be purely speculative, but that if the present rate of increase in the consumption of coal be indefinitely continued, even in an approximate degree, the progress toward the exhaustion of our coal will be very rapid."

This report has been severely criticised in the *British Quarterly Review* for July, 1872. The writer argues that there is no doubt that the increase of temperature is at least 1° Fahr. for every 55 feet in depth, and there is reason to believe that it follows an accelerating ratio. At Monkwearmouth mines the depth worked is 1,640 feet below the surface, and, in consequence of the high temperature, the men work shorter hours, which involves an increased expenditure. At Rosebridge, the deepest shaft in England, 2,376 feet, the temperature of the earth is 92°. At 2,690 feet the temperature reaches blood-heat (98°), in which continuous exertion is impossible. The limit to which coal can be extracted, before we commence a steady increase of cost, may be taken at 1,700 feet, and the limit of practicable extraction at 1,000 feet lower. No engineer, who has a reputation to lose, would venture to affix his name to a report that would contemplate the economical working of coal-mines at a lower depth than 2,700 feet. From 1,700 to 2,700 feet there must be a steady increase in the cost of working.

As to the quantity of unmined coal, the estimate includes every thing that is black, and that is more than 12 inches in thickness. It also includes the total cube quantity of coal. As to the very large quantity of coal believed to exist in undiscovered beds, the writer declines to regard the probability of its extraction as being at present a serious question. He figures up but 39,000,000,000 tons as the total quantity of available coal, and that, if the present rate of increase of consumption continues, the last ton of this will be extracted Anno Domini 1945.

It is a mathematical certainty that the exhaustion of a definite quantity of material which is consumed at an annually increased rate is only a question of time. But this is really a narrow and imperfect basis on which to solve the question, how long the supply of coal in England will hold out. It is really, he says, the question of the price at which coal can be laid down in an English port—comparing that paid for the produce of their own mines with that paid for the produce of other coal-fields, including freight—that must determine the question of the activity, or the disuse of the English collieries, whatever may be the amount of coal actually underlying the soil at that time. Within the last year (1872), a very large increase in the wages paid for mining labor, and a great advance in the prices of English coals, have taken place. The proverbial absurdity of "carrying coals to Newcastle" may yet be realized.

There are fifty-nine small coal-basins in France, of which the most important are those of the Loire, and those of St.-Etienne, which are the best known and the largest, comprising about 50,000 acres. In this basin are 18 beds of bituminous coal, and in the immediate neighborhood are several smaller basins containing anthracite. The total area of coal in France is probably not less than 2,000 square miles. In 1864, the Government engineers estimated there were 800,000 tons of anthracite coal produced, and of the 12,000,000 of tons, the mean average quantity obtained annually in France, at the present time, about 1,000,000 tons are hard anthracite, and the same quantity of softer anthracite, containing six or seven per cent. of oxygen and hydrogen. The coal-basins of France are on granite or metamorphic rocks, with beds or rather masses of coal of irregular and unequal thickness, sometimes attaining to 40, 60, and 80 feet, and in one or two places 130 feet in thickness, of a local character. Both in their size, and the granite on which they rest, they resemble the coal-basin near Richmond, Virginia.

Production of Coal in France, compiled from the Official Returns in the Report of the Royal Commission.

	Tons of 2,200 pounds.		Tons of 2,200 pounds.		Tons of 2,200 pounds.
1787	211,160	1848	4,017,875	1861	9,125,040
1788	220,982	1849	3,977,344	1862	10,102,116
1789	235,714	1850	4,354,840	1863	10,518,406
1802	829,105	1851	4,404,941	1864	11,046,794
1811	759,878	1852	4,816,306	1865	11,785,714
1816	924,823	1853	5,831,939	1866	11,807,142
1821	1,114,448	1854	6,709,535	1867	12,148,223
1826	1,513,482	1855	7,317,226	1868	12,800,000
1831	1,728 950	1856	7,784,165	1869	
1836	2,789,858	1857	7,755,987	1870	
1841	3,349,303	1858	7,221,267	1871	
1846	4,389,532	1859	7,337,326	1872	
1847	5,065,109	1860	8,155,394		

The Belgian coal-field is one of the most important in Europe, but not the most productive, and occupies two districts, that of Liege, containing 100,000, and that of Hainault, containing 200,000 acres. In each the number of coal-seams is very considerable, but the beds are so thin, and so much disturbed, as to require special modes of working, and they produce various qualities of coal. The small extent of the Belgian coal-field, says L. Simonin, is compensated for by the great number of the coal-seams, and by their numerous and singular zigzag contortions, which have the effect of increasing the quantity in a small, workable surface. All the seams, even to the very thinnest bands, have yielded to the elevating and compressing force, without being fractured, except at certain points; even the sharp bends in the angles having been produced without undergoing fracture. In this respect, the formation resembles our anthracite coal-fields.

The production of 1869 was represented by old Prussia, 23,761,-094; Saxony, 2,584,292; Bavaria, 340,571; and the other states of the Zolverein, 88,411; in all, 26,774,368 tons. The coal production of Prussia is larger than that of any other country in Europe. The brown coal included in the above statement is less than one-third of the whole amount.

In Prussia, the coal-measures are said to be 20,000 feet thick, containing 117 seams, in all 294 feet of coal. In another field there are 164 seams, over six inches thick, in all, 338 feet of coal; and of workable seams there are 77 seams with 240 feet of coal in a region 60 miles long by 20 miles wide. Some of the seams are 10, 12, and 14 feet thick, and it is extraordinary that the lowest known seams

are bituminous or caking coals, and, the higher they range in the series, the more dry or anthracite do they become. In Hungary, there is a brown coal of a good quality, in beds of the thickness of 50, 70, and even 120 feet.

Production of Coal in Belgium.

	Production.	Exportation.		Production.	Exportation.
1834		660,012	1854	7,947,742	2,625,958
1835		695,586	1855	8,409,330	2,974,349
1836	3,056,464	773,612	1856	8,212,419	2,866,137
1837	3,228,806	789,083	1857	8,383,902	2,887,012
1838	3,260,271	775,534	1858	8,924,714	3,091,316
1839	3,479,161	745,569	1859	9,260,702	3,145,235
1840	9,930,232	779,474	1860	9,609,895	3,450,306
1841	4,027,765	1,015,194	1861	10,057,163	3,379,409
1842	4,140,462	1,014,716	1862	9,758,223	2,840,337
1843	3,982,274	1,086,321	1863	10,160,590	2,839,348
1844	4,445,240	1,245,399	1864	10,959,078	3,264,243
1845	4,919,156	1,543,472	1865	11,629,163	3,503,978
1846	5,037,402	1,355,833	1866	12,546,541	3,971,272
1847	5,664,456	1,827,105	1867	12,544,038	3,564,308
1848	4,862,694	1,460,570	1868	11,755,956	
1849	5,251,843	1,664,973	1869	12,959,704	
1850	5,820,588	1,987,184	1870	13,496,564	
1851	6,233,517	2,057,050	1871	13,671,470	3,186,204
1852	6,795,254	2,103,546	1872		
1853	7,172,687	2,331,595			

Production of Coal and Brown Coal in Prussia (Silesia, Rhenish Provinces, Westphalia, and Saxony, etc.), now Germany.

YEARS.	Tons of Coal and Brown Coal.	YEARS.	Tons of Coal and Brown Coal.	YEARS.	Tons of Coal and Brown Coal.
1837	1,950,919	1863	16,906,707	1868	25,704,758
1857	9,841,220	1864	19,408,982	1869	26,774,368
1858	10,721,323	1865	21,794,705	1870	
1860	12,347,828	1865	21,628,746	1871	
1861	14,133,048	1867	24,738,327	1872	
1862	15,576,278				

In the province of Asturias, in old Castile, in the northern part of Spain, is a coal-field which in length reaches from the frontiers of France to those of Portugal, and in breadth at least eight or ten miles, and probably much more. It is said to contain 60 coal-seams, and other accounts say upward of 100 workable seams of bituminous coal, from 3 feet to 6½ feet, and some of them even 13½ feet thick, of the very best quality of coal, equal to that of Northumberland and Durham. These beds are variously inclined and contorted, often nearly vertical, and even reversed. The coal-fields of Asturias are likely hereafter to be ranked among the most valuable in Europe, but at present the production is small. Reducing their metric quintals

to tons of 2,240 lbs., the production in 1864 was 175,595 tons; in 1865, 208,864; in 1866, 177,776 tons; and 550,387 tons in 1869, besides 39,420 tons of lignite.

The great majority of the deposits of coal in Austria are found in the north-west portion of the empire, and the Tertiary deposits do not yield in importance to the more ancient formations. The following tabular statements contain all that would afford much interest to American readers.

Quantities of coal and brown coal produced in each province in 1862, that of Bohemia being the largest, the Austrian centners being reduced to tons of 2,240 lbs.:

PROVINCES.	Tons.	PROVINCES.	Tons.
Lower Austria	132,290	Galicia	120,816
Upper Austria	128,453	Dalmatia	7,886
Styria	490,981	Lombardy	.....
Illyria	120,413	Venetia	16,118
Coast-land	13,216	Hungary	561,832
Tyrol	4,832	Bannat	22,169
Bohemia	2,078,183		
Moravia and Silesia	828,594	Total	4,525,783

Production of Coal and Brown Coal in the Austrian States, in Gross Tons.

YEARS.	Tons.	YEARS.	Tons.	YEARS.	Tons.
1823	134,316	1840	469,662	1857	2,493,375
1824	149,280	1841	526,714	1858	2,887,543
1825	153,381	1842	519,825	1859	3,107,028
1826	171,308	1843	516,464	1860	3,476,088
1827	178,341	1844	639,168	1861	4,032,988
1828	171,371	1845	715,979	1862	4,525,783
1829	167,329	1846	793,823	1863	
1830	208,958	1847	827,409	1864	
1831	195,778	1848	No returns.	1865	
1832	212,140	1849	No returns.	1866	
1833	194,288	1850	1,116,998	1867	
1834	235,547	1851	1,354,487	1868	6,199,027
1835	248,792	1852	1,668,475	1869	6,685,112
1836	271,563	1853	1,736,342	1870	
1837	280,886	1854	1,842,252	1871	
1838	332,353	1855	2,084,375	1872	
1839	428,636	1856	2,319,838		

II. IN THE UNITED STATES.

There can be no more deceptive statement made in regard to the American coal-fields, which may be at the same time true, than that of their area only. But the reader, who is presumed to have read the preceding portion of this work, will be thereby enabled to discriminate between good and bad quality, thick and thin seams, their

nearness to the surface, and the facilities for mining and transportation to a good market; but especially between good and bad quality. In order that no one may be misled by mere size, the following tabular statement of the areas of the coal-fields in each State is accompanied by another, giving the annual production of each, so as to lead to a more just estimate of their present importance. The State of Kansas contains far more square miles of coal than Pennsylvania; yet the large bed in the little Hazleton Basin, five miles long, and less than one mile wide, is worth more than all the coal in Kansas. The fourth great coal-field, or that in the States of Iowa, Missouri, Nebraska, and Kansas, contains 64,887 square miles of surface, and great as is its importance in that vast, fertile, treeless, prairie country, yet it cannot be compared, in any respect but size, to the first or Alleghany coal-field in the States of Pennsylvania, Ohio, Maryland, West Virginia, Eastern Kentucky, Tennessee and Alabama, containing 58,737 square miles, the coal in the latter being so much better. But, in any view that may be taken, we should be content with our bountiful stores of coal, although it is not all of equally good quality.

Area of the Coal-fields of America, and their Annual Production.

STATES CONTAINING COAL.	Area in square miles.	Tons produced by Census Report, 1866—'70.	Tons produced in 1872. Estimated.
1. Pennsylvania Anthracite	472	15,648,437	19,000,000
" Bituminous	12,302	7,800,356	16,442,000
2. Maryland (Big Bed, 23 miles)	550	2,345,153	2,355,500
3. West Virginia (Taylor, 21,195)	16,000	608,878	700,000
4. Ohio	10,000	2,527,285	3,000,000
5. East Kentucky	8,983	35,488	40,000
6. Tennessee	5,100	133,418	200,000
7. Alabama (First Coal-field, 58,737)	5,330	11,000	15,000
8. Michigan (Second Coal-field)	6,700	28,150	30,000
9. Indiana	6,450	437,870	800,000
10. Illinois	36,800	2,624,163	3,000,000
11. W Kentucky (3d Coal-field 47,138)	3,888	115,094	300,000
12. Iowa	18,000	263,487	300,000
13. Missouri	26,887	621,930	700,000
14. Nebraska	3,000	1,425	1,500
15. Kansas (4th Coal-field, 64,887)	17,000	32,938	40,000
16. Arkansas	9,043	.....	.....
17. Texas	4,500	.....	.....
18. Virginia	185	61,803	62,000
19. North Carolina	310	.....	.....
20. Massachusetts, and 21. Rhode Island	500	14,000	14,000
Totals*	192,000	33,310,905	41,000,000

* The total area of the 37 United States is 1,950,171 square miles, without the Territories. The coal-area is, therefore, one square mile in ten. The area of the 10 Territories is 995,032 square miles, making an aggregate of 2,915,203 square miles. The area of lignite in the Territories is not known.

THE UTILIZATION OF COAL WASTE.

Description of E. F. Loiseau's Machinery.

The following is a description of the machinery which Mr. Loiseau intends to erect at Nesquehoning for the manufacture of anthracite coal dust, or waste, into "artificial fuel." A model occupying a space of six feet in length, two and a half feet in height and two feet in width, shows the entire process of manufacturing the fuel with great completeness.

The coal dust is dumped on a platform and pushed into the hopper of a stationary cylinder, in which revolves a shaft; to this shaft are fastened six radiating partitions, which divide the interior of the cylinder into six equal spaces; the coal dust fills these spaces, and the rotary motion given to the partitions carries it to an opening below, where it is discharged. A smaller hopper, close to the first one, receives the clay, previously dried and ground; this clay is carried through a smaller cylinder containing also revolving partitions, and is discharged in the same chute as the coal dust with which it mingles.

The space between the partitions of the clay cylinder is calculated to receive and discharge regularly five per cent. of clay, while from the larger cylinders *ninety-five* per cent. of coal dust is discharged. This dividing apparatus is very simple and mathematically correct.

The mixture of coal and clay, while falling under a chain elevator, is sprinkled with milk of lime and is raised in a moist condition, by said elevator, above the hopper of a conveyer in which it is discharged. A screw propeller revolving in this conveyer forces the materials into a mixer, where they are rapidly worked into a plastic mass by seven upright shafts, to each one of which four-teethed arms are fastened by set screws; these arms cross each other in all directions and thoroughly mixes the coal and the clay. By a very ingenious and new device, the shafts can all be removed and replaced, without removing the frame in which they stand.

Through suitable openings at the bottom of the mixer the plastic mass falls along a chute in the pug mill of the compressing machine, and is forced by a series of knives and a propeller fastened to central shaft through an aperture at the bottom between two moulding rollers having on their periphery a series of oval moulds. These rollers, revolving in opposite directions, receive between them, from the pug

mill above, the plastic mass in a continuous sheet and moulds it into *egg-shaped* lumps. The lumps are discharged under the rollers on an endless wire-cloth belt, to which motion is imparted by cast-iron balls (represented in the model by beads), these balls secure under the wire-cloth a rope, which strengthens it. The rollers, around which the wire-cloth belt revolves, have concave receivers wherein the balls successively fall, thus forcing the said belt to move forward and to discharge the coal into a hopper placed on top of the drying tunnel.

The feeding of the plastic mass to be compressed can be regulated in three different ways: 1st, by placing the knives inside the pug mill at any required angle. 2d, by increasing or reducing at will the number of revolutions of the shaft to which the knives are fastened, and 3d, by increasing or reducing the size of the aperture at the bottom through which the plastic mass is forced between the moulding rollers. The latter is done by dividing the bottom into two halves meeting obliquely downward and worked separately by a worm screw or by a lever (the model shows a lever to each half). By removing from one another the two halves of the bottom, or by bringing them nearer together, the size of the aperture between them is longitudinally increased or reduced.

The drying tunnel is heated by two fire-places, one at each end. It contains five moving endless wire cloth belts placed over one another, and so disposed that the balls move in a groove under each belt, so that the coal cannot fall from them. These belts revolve in opposite directions around rollers placed at each extremity of the tunnel.

The lumps of compressed coal discharged from the press-carrying belt, fall in the dry-tunnel on the top belt and are carried by it the entire length of said tunnel, where they fall on an apron which guides them to the second belt below; on this belt the coal travels again in the opposite direction the entire length of the tunnel; it is then discharged on another apron, along which it slides on the third belt below, and so on from the third belt to the fourth and from the fourth to the fifth. This last belt carries the coal out of the tunnel and discharges it into the buckets of an elevator by which the coal is raised and discharged on the "waterproofing belt." This belt is guided by balls on each side in an open tank, on the sides of which are grooves describing a curve. This tank is kept filled with the waterproofing compound, supplied from a larger tank near by; the belt has small partitions to prevent the sudden fall of the lumps in the mixture and

to rake them out of it; the balls moving in the curved grooves immerse the coal continually in the waterproofing liquid. When coming out of the bath, the liquid in excess on the coal falls in drops through the wire cloth into a gutter placed under it and through a pipe in a suitable vessel.

The waterproof compound used by Mr. Loiseau is rosin or any other gum dissolved in benzine. To evaporate rapidly this benzine, the coal coming out of the bath is discharged into the hopper of a second tunnel of smaller proportions than the drying tunnel, in which there are only three belts placed one above another. A blower forces into this tunnel a strong supply of air, which evaporates the benzine, while the coal is travelling from one belt to the other. From the third and last belt the coal falls through a chute into the coal car standing outside. The end of the chute can be raised to allow time for the removal of a loaded car and the placing under the chute of an empty one.

The motion given to the coal in the tunnel brings only a few lumps in contact with one another, thus giving to all the lumps the full benefit of the heated atmosphere and drying them more rapidly. In Europe the coal is still piled up in cars with perforated sides and bottom and baked in ovens, which requires much time, unnecessary handling and consumes a large amount of fuel.

Mr. Loiseau shows by full-sized models how the balls (represented in the small model by beads), are fastened to the wire-cloth belts and to one or two wire ropes.

From the moment that the coal dust is pushed into the coal hopper, the whole process of manufacturing it into artificial fuel is carried on automatically. The coal dust and the clay are mixed in the required proportions with the milk of lime; these materials are carried, mixed, compressed into lumps, dried, made waterproof, the benzine is evaporated and the coal is loaded on cars ready for market all by machinery. During the entire process the coal is constantly in motion.

The process itself, and the machinery for its application, are the invention of Mr. Loiseau.

For ten months Mr. Loiseau has been experimenting at Nesquehoning with machines erected by another company, and he has been enabled to judge practically of all the difficulties in the way of the manufacture of artificial fuel from anthracite coal dust, and to profit from the failure of others. Mr. Loiseau's work at Nesquehoning, has been under the auspices of the Lehigh Coal and Navigation Company.

ON THE MOLECULAR CHANGES PRODUCED IN IRON BY VARIATIONS OF TEMPERATURE.

By Prof. R. H. Thurston.

(Continued from page 203.)

42. David Kirkaldy, of Glasgow, in December, 1860, while conducting one of the most extended, accurate and well-arranged experimental inquiries into the value of the tenacity of iron and steel that has yet been made,* took occasion to examine the action of frost upon them.

"A bar of Glasgow B, best ¾-inch diameter, was converted into ten bolts, in the ordinary way. Six were exposed all night to intense frost, and tested in the morning with the thermometer at 23° Fahr. The others were kept in a warm place, and carefully protected during testing. Three were tested with gradual, and seven with sudden strains." "When the strain was gradually applied, there was very little difference between the specimens tested in the ordinary condition and the two that were frozen; the former bore 55,717; the latter, 54,385; or 2·1 per cent. less. The difference, under sudden strains is somewhat greater, viz., 3·6 per cent. less when frozen." This iron was of good quality, and Kirkaldy remarks that "had it been of a coarser description, the difference, when frozen, might have been much greater." He concludes† that "the breaking strain is reduced when the iron is frozen; with the strain gradually applied, the difference between a frozen and an unfrozen bolt is lessened as the iron is warmed by the drawing out of the specimen."

Kirkaldy noticed that "The amount of heat developed is considerable when specimen the is suddenly stretched"—an important circumstance which had previously escaped the observation of experimenters.

43. This subject was debated at some length at meetings of the Manchester Literary and Scientific Society, some two years ago, and experiments were described which afforded data of value and interest.

Mr. William Brockbank described his experiments, made for the purpose of determining the effect of cold upon the cohesion of cast-

* Experiments on Wrought-Iron and Steel; David Kirkaldy, Glasgow, 1863; p. 85.

† Ibid., p. 95.

iron. Using a mixture of several irons of quite different qualities (Cleator red hematite, Pontypool and Blaenavon cold blast and Glengarnock hot blast irons, with scrap added), he found a perceptible decrease of strength with decrease of temperature. He noted a similar effect where wrought-iron was used. The experience of well-known ironmasters was adduced in corroboration of these conclusions, the examples being, usually, instances of breakage by *shock*. The conclusion of the experimenter* was that "bar iron, boiler plate, wire billets and rails are most materially weakened by the action of intense cold, losing their toughness, becoming quite brittle under sudden impact, and having their structure changed from fibrous to crystalline."

44. Sir William Fairbairn stated the results of his experiments, substantially as has been already given, attributing the more frequent breakage of wheel tyres in cold weather, to which allusion had been made, to unequal strains due to shrinkage, rather than to loss of tenacity.

45. Dr. Joule gave an account of his own experiments, upon a smaller scale, made at temperatures of 12° and 55° Fahr., with weights applied without shock. The result indicated an increase of strength at the lower temperatures, in the proportion of $58\frac{1}{8}$ to $59\frac{5}{6}$, or $2\frac{1}{2}$ per cent. as a mean of twelve experiments. Experiments, 41 in number, in which the breakage was produced by shock, gave the opposite result. These experiments were made upon large steel needles, and upon cast nails. They have been sometimes ridiculed as too insignificant to afford valuable evidence, but, insignificant as they may appear, and roughly made as they undoubtedly were, they are valuable as giving corroborative evidence of the fact which has already been quite proven, that decreasing temperatures, in general, produce increased strength, but decreased elongation and resilience.

He concludes that "Frost does *not* make either iron (cast or wrought) or steel brittle, and accidents arise from the neglect of the companies to submit wheels, axles, and all other parts of their rolling stock to a practical and sufficient test before using them.

46. Mr. Peter Spence gave a description of his experiments upon bars of cast-iron, one-half inch square, placed on supports nine inches apart, and broken by carefully applied and steady pressure.

Six experiments were made at 60°, and six at 0° Fahr. He sums up the evidence thus:

* Nature, 1871.

"The bars at zero broke with more regularity than at 60°, but, instead of the results confirming the general impression as to cold rendering iron more brittle, they are calculated to substantiate an exactly opposite idea, namely, that reduction of temperature *cæteris paribus*, increases the strength of cast-iron." He found this increase to amount to 3½ per cent. between 60° and 0°.

47. Subsequently, Mr. Spence made a more extended series of experiments.

He obtained 50 bars of cast-iron (of mixed Scotch brands), each three feet long and one-half inch square, cut them into lengths of one foot, and mixed them thoroughly. Seventy pieces were tested at zero, after 48 hours exposure to a freezing mixture of salt and ice, and seventy were tested at 70° Fahr.

The breaking weights of the pieces averaged 430·3 lbs., warm, and 442·8 lbs. at zero, the weight being placed midway between supports nine inches apart.

Mr. Spence finally says:* "I have no hesitation in giving it as an ascertained law, that a specimen of cast-iron, having, at 70° Fahr., a given power of resistance to transverse strain, will, on its temperature being reduced to 0°, have that power increased three per cent."

Mr. Spence notices a circumstance, which occurred in the course of his experiments, which may throw some light upon the molecular constitution of metals and thus, indirectly, upon the subject discussed. A weight of 449 lbs. had been suspended from one of the bars tested, for the space of nearly two minutes; the bar finally broke after a single one lb. weight had been, without the slightest jar, lifted off—so slowly, in fact, that its upward motion was barely perceptible. It may be imagined that the fact is new evidence of the existence of viscosity in even cold iron.

48. The most complete investigation ever made, particularly to determine the effect of changes of temperature in modifying the physical properties of iron and steel, was that of Knuff Styffe, the director of the Royal Technological Institute at Stockholm, Sweden, and supplemented by the experiments of Christer P. Sandberg, who translated the report of Styffe into English.

The work of the first-named engineer was done at the instance of a committee appointed by the King of Sweden. It was commenced by Professor Angstrom, continued by Herr R. Thalen, of the University of Upsala, and by Engineer K. Cronstrand, and it was finally

* London *Engineering*, 1871; vol. 11, p. 172.

concluded, with the assistance of Cronstrand and Lindell, by Styffe, who wrote out the results of the whole investigation and made the report public.

These labors were begun in 1863, and extended over several years.

The conclusions of Styffe were:

"(1). That the absolute strength of iron and steel is not diminished by cold, but that, even at the lowest temperature which ever occurs in Sweden, it is at least as great as at ordinary temperature (about 60° Fahr)."

"(2). That, at temperatures between 212° and 392° Fahr., the absolute strength of steel is nearly the same as at ordinary temperature, but in soft iron, is always greater."

"(3). That neither in steel nor in iron is the extensibility less in severe cold than at ordinary temperature, but that, from 266° to 320° Fahr., it is generally diminished, not to any great extent in steel, but considerably in iron."

"(4). That the limit of elasticity, in both steel and iron, lies higher in severe cold; but that at about 284° Fahr., it is lower, at least in iron, than at ordinary temperatures."

"(5). That the modulus of elasticity in both steel and iron is increased on reduction of temperature, and diminished on elevation of temperature; but that these variations never exceed 0·05 per cent. for a change of temperature of 1·8° Fahr., and, therefore, that such variations, at least for ordinary purposes, are of no special importance."

49. An equally well conducted series of experiments on transverse strength and the flexure of iron and steel led to the following conclusions:

"(1). Iron sustains, at lower temperatures, a greater, and at higher, a smaller load than at the ordinary temperature, before it obtains any perceptible permanent deflections."

"(2). The modulus of elasticity for steel and iron on flexure, may, for practical purposes, and without committing any considerable error, be generally assumed equal to that on traction. It is diminished by permanent deflection, but may be restored by heating, especially if raised to a red heat."

"(3). By hardening steel, its modulus of elasticity is diminished, but this diminution has not, in any of the hardened bars examined, amounted to more than about three per cent."

"(4). The elastic force of iron and steel on flexion, as on traction,

is increased on reduction of temperature and diminished on elevation of temperature. The amount of this increase or decrease for a change of temperature equal to 1·8° Fahr. (1° centigrade) does not, however, in general, amount to more than 0·03 per cent., and, apparently, never rises to 0·05 per cent."

50. The experimenter states that "the results of the experiments given above are evidently opposed to the opinion hitherto commonly entertained, viz., that steel and iron become weak or brittle at low temperatures," and gives it as his opinion that the cause of the frequent breakage of rails in cold weather, and of articles made of iron and steel, is unequal expansion and contraction and the rigidity of supports, where, as is the case with rails, frost may very greatly affect them.

51. Sandberg, while admitting the care and the accuracy which distinguished this extensive series of experiments, still doubted whether the reasons just given were the sole reasons why metals should more readily break in cold than in hot weather, and, having obtained the consent of the State Railway Administration, he conducted a series of experiments, in the summer and winter of 1867, at Stockholm, to determine whether, with equal rigidity of supports, iron rails would yield with equal readiness to blows at the two extremes of temperature.

The rails experimented upon were each cut in two halves, and one piece was tested in cold, and the other warm, weather, at temperatures of 10° and 84° Fahr. respectively. The supports at the ends of the rails were granite blocks, placed four feet apart, and resting on the smoothly levelled surface of the granite rock. They were broken by a heavy drop, weighing nine cwt.

Sandberg's conclusions, from 20 experiments, are thus given:

"(1). That, for such iron as is usually employed for rails in the three principal rail making countries (Wales, France and Belgium), the breaking strain, as tested by sudden blows or shocks, is considerably influenced by cold; such iron exhibiting, at 10° Fahr., only from one-third to one-fourth of the strength which it possesses at 84° Fahr."

(2). That the ductility and flexibility of such iron is also much affected by cold; rails broken at 10° Fahr., showing, on an average a permanent deflection of less than one inch, whilst the other halves of the same rails, broken at 84° Fahr., showed a set of more than four inches before fracture."

"(3). That, at summer heat, the strength of Aberdare rails was 20 per cent. greater than that of the Creusot rails; but that, in winter, the latter were 20 per cent. stronger than the former."

Sandberg suggests that this considerable decrease of toughness at low temperatures may be due to the "cold shortness" produced by the presence of phosphorus.

Our knowledge on this point must remain imperfect until similar experiments have been made with iron free from phosphorus.

52. The researches above described constitute the experimental basis of our knowledge of the effect of change of temperature in producing alterations of molecular structure and of strength and resilience in metals.

A few other less elaborate, though instructive, experiments have been made, some of which enlarge our knowledge of molecular physics somewhat, although bearing less directly upon the problem under consideration.

53. Professor W. F. Johnson, in 1844, gave the results of experiments made under the direction of the United States Navy Department, which revealed the fact that the increased strength, at moderately high temperatures, which was noted by the committee of the Franklin Institute, was retained, on cooling, provided that the bars were submitted to powerful tension while heated.

Prof. Johnson reports* that "the average gain of length of bolts of iron treated at the Washington Navy Yard, by this same process, was 5·75 per cent., and the gain of strength 16·64, making, together, the gain of value 22·4 per cent.

"In many instances the experiments made at the Franklin Institute proved the gain of length to exceed 7 per cent. The report to the bureau also confirms what had been previously observed, viz., that the total elongation of a bar of iron, broken in its original cold state, is from two to three times as great as the same force would produce upon it if applied at a temperature of 573°, which force, will, moreover, not break the bar at that temperature."

54. Professor Thompson has indicated† the existence of a resistance to molecular movement, such as has been referred to already, and designated "molecular friction." He calls it "viscosity." The term, thus used, designates a somewhat different property from that

* Senate Document, No. 1, 1844—5; and American Journal of Science and Arts, 1846, vol. 1, p. 300.

† Civil Engineers' Journal, Vol. 28.

to which the name is generally applied, and which was illustrated by Tresca's experiments, already described, and other similar experiments.

He deduced the following:

(1). That there is a certain internal resistance which is independent of the elastic properties of metals.

(2). That it does not affect the coefficient of elasticity.

55. A singular action has been recently detected by W. H. Johnson,* which may prove instructive in this connection.

Iron was immersed in hydrochloric acid one or more hours, and then tested for elongation and breaking strain. The pieces were then heated, and again tested with the following results:

"(1). That immersion in acid diminishes the breaking strain of iron wire from $\frac{1}{2}$ to 3 per cent., and of steel wire about 4·76 per cent.

"(2). That immersion in acid appears, in some cases, to diminish, and, in others, slightly to augment the elongation of iron wire, and to augment the elongation of steel wire about 30 per cent."

Heat restored to the iron its original toughness.

Pyroligneous and sulphuric acids had the same effect as hydrochloric, in different degrees.

Copper was not affected in this manner.

The cause of this peculiar action remains undetermined. The phenomenon is of interest principally as confirming an inference deducible from other experiments, viz., that, in general, circumstances tending to increase the strength of a metal, by molecular change, also tend to reduce its viscosity and its extensibility, and *vice versa*.

56. The experiments of Mr. Oliver Williams,† in determining the change produced in the character of the fracture of iron by transverse strain, at extreme temperatures, were more evidently pertinent to this subject.

Mr. Williams says, of two specimens of nut iron, cut from different bars, made at Catasauqua, Pennsylvania, "These specimens were first nicked with a cleft on one side only, and then broken under a hammer, at a temperature of about 20° Fahr. At this temperature, both specimens broke off short, showing a clearly defined granular, or steely iron fracture. The pieces were then gradually heated to about 75° Fahr., and then broken, as before, developing a

* "Iron," April, 1873, p. 452.

† *The Iron Age*, New York, March 13, 1873, p. 16.

fine, clear, fibrous grain. The two fractures were but four inches apart, and are entirely different."

57. It has been long known that a granular fracture may be produced by a shock, in iron which appears fibrous when gradually torn apart.

This was fully proven by Kirkaldy.* Mr. Williams was, probably, the first to make the experiment just described, and thus to make a direct comparison of the characteristics of fracture in the same iron at different temperatures.

A fair inference from these experiments is, apparently, that a reduction of temperature increases the polarizing force, decreases the viscosity of the metal, and thus causes its fracture to assume the appearance which characterizes the fracture of substances which are remarkable for their rigidity; while elevation of temperature, increasing viscosity, allows greater extension before fracture, and this greater toughness is evidenced by the sort of fracture characteristic of less brittle materials.

58. Nothing in these experiments affords any indication of the effect of change of temperature, in this instance, upon the strength of the metal. It has, however, been shown that low temperatures increase the strength of metals, and Mr. Williams' experiments are confirmatory of the supposition, of which strong evidence has already been quoted, that it also *decreases* resilience, or the power of resisting blows and heavy shocks.

The experience of every mechanic who has observed the behavior of tools and of metals at different temperatures, also confirms this belief. Tools yield readily to blows, where exposed to severe cold, although not evidently weak under steady strain.

59. It has been remarked (Article 22), that we should anticipate that the effects of change of temperature would be most marked with metals of low melting points.

The observations of Prof. Fritzsche, who noticed that extreme cold produced upon tin an effect somewhat similar, but even more striking than that remarked by Mr. Williams in the case of iron, may be accepted as corroborating this idea.

The well known variations in the ductility of zinc, when under varying conditions of temperature, are also noticeable evidence of marked rapidity of such changes, where the range of temperature, within which the body remains solid, is narrow.

* Experiments on Iron and Steel.

60. Reviewing the whole ground, it becomes evident that there still remains much interesting work to be done in determining the precise effects of variation of temperature upon the strength and ductility of the various metals, and, particularly, in ascertaining the modifications of the general law, which may be due to differences in physical and chemical structure, where they are combined with the metalloids, or united as alloys.

Some of those effects which have been attributed to changes of tenacity in the material may have been due, in some degree, to unequal expansion or contraction. It can hardly be doubted that such action often modifies, or even disguises, the change in character produced by real changes of intermolecular forces. It is certainly the fact that changes of molecular arrangement sometimes occur very slowly.

Ordnance of cast-iron has been found to gain strength slowly, but probably steadily, for years after its removal from the foundry; the familiar belief that razors, out of use, recover the cutting quality lost by constant employment, may be probably founded on fact, and the writer has often noticed that cold chisels and similar tools, when found after long disuse and exposure to the weather, seem to have regained the strength and endurance of edge, the loss of which had probably caused the workmen to throw them aside.

If this be the case, a sudden alteration of structure, such as may be produced by considerable changes of temperature, may cause a change of quality, which only a long period of time may counteract. Such action would evidently be most marked with brittle, and least noticeable with ductile, metals, and the fact is further illustrated by the circumstance that *iron* castings, not infrequently, are broken while cooling after removal from the mold, while *bronze* castings are very rarely thus injured.

61. It seems, finally, very probable that additional investigation will be found to confirm our deductions from experiments already made, and will justify the following

CONCLUSIONS:

1. That the number and the nature of those molecular forces which determine the physical condition of matter are not yet fully ascertained, but that these forces manifest themselves in, at least, three distinct modes of action, and, as thus exhibited, they are known as repulsion, cohesion and polarity.

2. That the force of repulsion is, apparently, heat-motion, or some closely related phase of energy; that the force of cohesion bears some resemblance to that of gravitation, but seems not to be identical with the latter, and that the force of molecular polarity, which determines the molecular relations of position, seems to bear some distant resemblance to that of magnetic polarity.

3. That the law which governs the variations in intensity of these forces with changes of intermolecular distances, is undetermined, and that it has not been expressed by any mathematical formula, except approximately and for a limited range.

4. That the magnitudes of the intermolecular spaces, and, consequently, the volume of any mass, are variable with changes in the relative magnitudes of the forces of cohesion and repulsion.

5. That the resistance offered to change of form is determined by the relations, in intensity, of the forces of polarity, and of those forces which determine intermolecular distances.

6. That, at the "absolute zero" (—461·2° Fahr.), cohesion and, consequently, the strength of the material, have their maximum value, heat energy having disappeared.

7. That, at very high temperatures, heat energy exerts a separating force between particles, which entirely overcomes the other forces, and matter assuming the gaseous state requires the action of extraneous force to preserve its volume unchanged.

8. That, at intermediate points, matter in either the solid or the liquid state exhibits a definite degree of separation of molecules, which is determined by the intensity of the repulsion due to heat motion, a position of equilibrium being assumed which, with the same substance, is invariable for the same temperature. The application of some kind of force is required to disturb this equilibrium and to produce this change of volume. The amount of this force is determined, for any given extent of disturbance, by the maximum value of cohesion for the substance and the quantity of heat which has been required to raise it from the absolute zero of temperature. The sum of the applied force, and of the force consequent upon the presence of heat motion, must exceed cohesive force to produce dilatation, while this cohesive force, added to the externally applied force, must exceed the force of repulsion to produce diminution of volume.

9. That the distinction between the solid and liquid states of matter is due to the action, in the former, of the force of polarity, which

gives stability of form, while in the latter this force is extremely feeble, and disappears altogether before the boundary line between the liquid and gaseous states is reached.

That combined stability and elasticity of volume may be produced by the equilibrium of attractive and repulsive forces, but that stability and elasticity of form demand the coexistence of cohesion and polarity.

10. That the general effect of increase or decrease of temperature is, in solid bodies, to decrease or increase their power of resistance to rupture, or to change of form, and their capability of sustaining "dead" loads.

11. That the general effect of change of temperature is to produce change of ductility, and, consequently, change of resilience and power of resisting shocks and of carrying "live" loads. This change is opposite in direction and, usually, greater in degree, than the variation simultaneously occurring in tenacity.

12. That marked exceptions to this general law have been noted, but that it seems invariably the fact that wherever an exception is observed in the effect upon tenacity, an exception also may be detected in the effect upon resilience. Those causes which produce increase of strength appear always to cause a simultaneous decrease of ductility, and *vice versa*.

13. That experiments upon copper, so far as they have been carried, indicate that, with that metal, the general law holds good.

14. That iron exhibits marked deviations from the law, between ordinary temperatures and a point somewhere between 500° and 600° Fahr., the strength increasing between these limits to the extent of about 15 per cent., with good iron. That this variation becomes more marked and the observed effects are more irregular as the metal is more impure.

15. That, above 600°, and, at temperatures below 70° Fahr., the general law holds good with iron, its tenacity increasing with diminishing temperature below the latter point, at the rate of from about 0·02 per cent to 0·03 per cent., for each degree Fahrenheit, while its resilience decreases in a much higher but not well determined ratio for good iron, and to the extent of reduction to one-third its ordinary value or less, at 10° Fahr., when "cold short," and, in the latter case, the set before fracture may be less than one-fourth that noted at a temperature of 84° Fahr.

16. That the viscosity, ductility and resilience of metals are deter-

mined by identical conditions, and that the fracture of iron at low temperatures has, accordingly, been found to be characteristic of a brittle material, while, at higher temperatures, it exhibits the appearance peculiar to ductile and somewhat viscous substances. The metal breaks, in the first case, with slight permanent set and a short, granular fracture, and in the latter with, frequently, a considerable set and the form of fracture indicating great ductility. The variation in the behavior of iron, as it approaches the welding heat, illustrates the latter condition in the most complete manner.

17. That the precise action of the elements with which iron is liable to be contaminated, and the extent to which they modify its behavior under varying temperatures, remain to be fully investigated, but that the presence of phosphorus, and of other substances producing "cold shortness," exaggerates to a great degree the effects of low temperature in causing loss of toughness and resilience.

18. That the modifications of the general law with other metals than iron and copper, and in the case of alloys, have not been studied, and are entirely unknown.

19. That these conclusions are sustained by experiments of both physicists and engineers.

The practical result of the whole investigation is that iron and copper, and probably other metals, do not lose their power of sustaining "dead" loads at low temperatures, but that they do lose, to a very serious extent, their power of sustaining shocks or resisting sharp blows, and that the factor of safety in structures need not be increased in the former case, where exposure to severe cold is apprehended, but that machinery, rails and other constructions which are to resist shocks, should have large factors of safety, and should be most carefully protected, if possible, from extremes of temperature.

It will be noticed that nothing in the evidence here quoted indicates crystallization or any change of molecular grouping to be consequent upon simple change of temperature.*

Stevens' Institute of Technology, Hoboken, N. J., May, 1873.

* It is intended to consider this subject in a succeeding paper.

ABSTRACT OF A PAPER ON THE DURABILITY AND PRESERVATION OF IRON SHIPS, AND ON RIVETED JOINTS.

By Sir William Fairbairn, Bart.; F.R.S.*

The disaster which happened to the "Megæra" is first discussed, as showing the need of constant inspection of iron structures. That vessel was built by the author of the paper in 1849, and, in his opinion, would have been perfectly sound at the present time if her interior had been freely open to inspection, and if such inspection had been regularly carried out. Some years ago an alarming report was circulated as to the corrosion of the Menai Bridge. The author on that occasion visited the bridge, and found that no corrosion had taken place, careful attention to proper means of prevention having been sufficient to preserve the structure. The proved value of periodical inspections in the case of steam-boilers is then alluded to, and the author urges the importance of similar inspections of iron ships by the Admiralty and by private shipowners.

As respects riveted joints, the author first discusses the relative merits of machine- and hand-riveting, and points out that in machine-riveting there is much greater security that the rivets properly fill the rivet-holes. The rate at which riveting can be done is given as 16 rivets per minute with a lever riveting-machine, 10 rivets per minute with a steam riveting-machine, and 0.66 rivet per minute when the riveting is done by hand.

Experiments on Riveted Joints.

The author alludes, first, to the series of experiments on riveted joints which were communicated by him to the Royal Society in 1850. Those experiments showed that, taking the strength of a solid plate at 100, the strength of an equal width of riveted joint would be 70 if the joint were double riveted, and 56 if the joint were single riveted: in other words, 30 per cent. of strength is lost in a double-riveted joint, and 44 per cent. in a single-riveted joint. Since that time it has appeared to some engineers that the process of punching was injurious to the plates, and in many cases recourse has been had to drilling to form the rivet-holes. On this point the author was of opinion that with good iron no sensible injury resulted from punching the rivet-holes; on the other hand, with rigid and bad plates, the plate would crack between the rivet-holes, and the plate would

* Proceedings of the Royal Society, Vol. xxi, 259.

have to be discarded. He regarded it as a distinct advantage of the punching-process that it thus tested the quality of the iron. It had been found in certain cases that the rivets sheared across with a less force when in drilled than when in punched holes, and this had been attributed to the sharpness of the edges of the drilled holes. This point seemed to require investigation, and experiments to elucidate it had, therefore, been made, the results of which are narrated in the paper. The theory that the sharp edges of drilled holes induced a cutting action, which diminished the strength of the rivets, had suggested to Colonel Inglis, R. E., to try whether a greater resistance in the joint could be obtained by purposely rounding the edges of the rivet-holes. Some experiments had been made for Colonel Inglis by Mr. Kirkaldy, from which it appeared that the resistance of the rivet was increased 10 per cent. by this rounding of the edges of the rivet-holes. The author has also experimented on this point, and the results of his experiments are given in the paper.

A series of tables of experiments are then given, each result being fully discussed. The following table is a summary of results obtained by the author:

Experiments on the Ultimate Resistance of Rivets to Shearing.

No. of experiments.	Diameter of rivet, in decimals of an inch.	Sectional area of rivet, in decimals of a square inch.	Shearing resistance of rivet, in tons.	Shearing resistance, in tons per square inch.	Elongation of joint, in decimals of an inch.	REMARKS.
1.....	·84	·554	10·819	19·528	·190	Single shear; punched holes; machine-riveted.
2.....	·82	·528	10·879	20·606	·272	Single shear; punched holes; hand riveted.
3.....	·84	·554	10·257	18·514	·168	Single shear; drilled holes; machine-riveted.
4.....	·82	·528	10·739	20·339	·190	Single shear; drilled holes; hand-riveted.
5.....	·84	.554	11·221	20·254	·270	Single shear; drilled; edges of plates rounded; machine-riveted.
6.....	·82	·528	11·192	21·197	·240	Single shear; punched and countersunk; hand-riveted.
7.....	·84	·554	10·850	19·584	·160	Single shear; drilled and countersunk; machine-riveted.
8.....	·82	·528	11·234	21·276	·288	Single shear; drilled; edges rounded; countersunk; hand-riveted.
9.....	·82	·528	22·375	44·270	·340	Double shear; punched; hand-riveted.
10.....	·82	·528	20·684	39·174	·232	Double shear; drilled; hand-riveted.
11.....	·82	·528	24·313	46·047	·482	Double shear; drilled; edges rounded; hand-riveted.
12.....	·82	·528	26·464	50·121	.....	Double shear; drilled; edges rounded and countersunk; hand-riveted. (This rivet did not shear. The plate broke away.)

The general conclusions drawn by the author from his experiments are as follows:

(1) *Joints with drilled holes are weaker and elongate less before fracture than joints with punched holes.* The average of four experiments on joints with drilled holes, compared with the average of four experiments on joints with punched holes, shows that the rivets in the former are 1·36 ton per square inch, or 6½ per cent., weaker than the rivets in the latter. The elongation is also 26 per cent. less with drilled than with punched holes.

(2) *Hand-riveted joints are somewhat stronger than machine-riveted joints.* The mean of three experiments on hand-riveted joints, compared with the mean of three experiments on machine-riveted joints, shows an excess of shearing resistance in the rivets in the hand-riveted joints amounting to 1·495 ton per square inch, or 7¼ per cent. The hand-riveted joint also elongates 26 per cent. more than the machine-riveted joint.

(3) *There is a decided increase in the strength of the rivet when the edges of the rivet-holes are rounded, so as to diminish their cutting action.* The mean of three experiments on joints with rounded holes, compared with the mean of three experiments on joints with unrounded punched holes, and with the mean of three experiments on joints with unrounded drilled holes, gives the following results:

		Shearing resistance of rivet.
Rounded holes,		21·517 tons per sq. in.
Unrounded holes,	punched,	20·958 " "
	drilled,	19·228 " "

This shows that the joint with rounded holes is, as regards the resistance of the rivet, 12 per cent. stronger than the joint with drilled holes, but only 2¾ per cent. stronger than the joint with punched holes.

As regards the apparent superiority of hand-riveting as compared with machine-riveting, the author observes that this is due to the fact that in hand-riveted joints the rivet is slightly hardened by being hammered after it is cold. In small experimental joints hand-riveting has therefore a slight advantage in strength; but the defects of hand-riveting are not likely to be exhibited in experiments on a small scale.

The experiments seem conclusive as to the inferiority of joints with

drilled holes; and the author reiterates his conviction that the force used in punching plates is a valuable practical test of their quality, and tends to prevent the use of inferior iron.

Franklin Institute.

Proceedings of the Stated Meeting, May 21, 1873.

The meeting was called to order at the usual hour, with the President, Mr. Coleman Sellers, in the Chair.

The minutes of the previous meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that at the stated meeting of the Board, held May 14th, donations to the Library had been announced from the following:

Machinery of the Arabia and La Plata. From B. H. Bartol, Esq., Philadelphia.

Bulletin of the National Association of Wool Manufacturers, Boston, Mass. From the Association.

Journal of the Society of Arts of London, for March, 1873. From the Society.

Annales des Ponts et Chaussées, Paris, France. From the Administration.

Monthly Notices of the Royal Astronomical Society, for March, 1873. From the Society.

Mittheilungen der K. K. Geographischen Gesellschaft in Wien, 1871. From the Society.

Statistical Report of the National Association of Iron Manufacturers for 1872. From the Association.

Proceedings and Statistics of the American Pig Iron Manufacturers' Association for 1872. From the Secretary of the Association.

The Report of the Superintendent of the U. S. Coast Survey, showing the progress of the Survey during the year 1869. From Prof. Benj. Pierce, Superintendent U. S. Coast Survey.

The Hub and Coach Makers' Magazine. From John H. Warder, Esq.

Annales de Chimie et de Physique for January and February, 1873. From the Editors.

Comptes Rendus Hebdomidaires des Sceances de l'Academie des

Sciences, from December 30th to March 24th, 1873. From the Academy.

Bulletin de la Société d'Encouragement pour l'Industrie Nationale, January to April, 1873. From the Society.

Revue Genérale de l'Architecture et des Travaux Publices, etc. From the Editor.

General Register der Bände, xi—xx, des Jahrbuches und der Jahrgänge, 1860—to 1870, der Verhandlungen der K. K. Geologischen Reichsaustalt. From the Direction.

Jahrbuch der K. K. Geologischen Reichsanstalt Jahrgang, 1872, from October to December. From the Direction.

Verhandlungen derselben, 1872. From the same.

Third Annual Report of the President and Directors of the Lake Shore and Michigan Southern Railroad. From Chas. Paine, Esq.

Annales des Pontes et Chaussées, for January, 1873. From the Administration.

Annales des Mines, etc. Vol. ii, 1872. From the Administration.

Proceedings of the Academy of Natural Sciences, for January and February, 1873. From the Academy.

Transactions of the American Society of Civil Engineers. Proceedings of the meeting held January 17th, 1873. From the Society.

The Actuary likewise deposited the minutes of the several standing committees.

The special committees on the Horse-Power of Steam Boilers and upon Conflagrations, reported progress, and were continued by direction of the President.

The President next announced a paper upon an improved form of furnace for the desulphurization of gold ores, by Dr. Ira M. Phelps. The paper will be found published in the Journal of the Franklin Institute for August, 1873. The speaker described the progress made in the utilization of the sulphurous ores of the West, and explained from photographs cast upon the screen, the construction of a new furnace, which he claimed would accomplish the object more efficiently.

The paper elicited some discussion, which was participated in by R. E. Rogers, the President and the speaker.

The next paper announced was by Col. A. S. Gear, of Boston, Mass., upon A New Stone Working Machine. The speaker, after a general description of his device, and its peculiar advantages, referred to the samples of dressed and ornamental specimens of various

stones, which lay upon the table for inspection, as evidences of the capacity of the machine.

The paper in question will be found published in the Journal of the Institute for October, 1873.

Under the head of deferred business, the President announced the consideration of a resolution, presented by Mr. S. Lloyd Wiegand, at the last meeting of the Institute, as follows:

"*Resolved*, That a special committee of five members be appointed by the Chair, and announced at the next meeting of the Institute, to inquire into the expediency of introducing a system of uniform standard screw-threads, for tubing, and if, in their judgment, it appears expedient, to report such a system to be recommended by the Institute to manufacturers, for general adoption."

Mr. Wiegand moved to refer the subject of his resolution to the Committee on Sciences and the Arts. Carried.

Under the head of new business the President stated the business of the meeting to be the consideration of the motion of Mr. Robert Briggs, of which notice was given by Mr. Briggs at the last meeting, namely, to abolish Section 2d of Article xi of the By-Laws, referring to the Committee on Science and the Arts.

Mr. Briggs, in defence of his motion to abolish, made an address to the Institute, the tenor of which was to show that the period of usefulness of a committee, so constituted as the one under consideration, had passed.

Mr. John C. Cresson, in reply, gave a review of the past history of the Committee, and its opportunities for usefulness at present.

Mr. Orr followed with similar tenor, and in conclusion moved to indefinitely postpone the motion to abolish.

Mr. Cresson requested a withdrawal of the motion to postpone, in order that a square action might be had upon the motion to abolish. By consent, Mr. Orr withdrew his motion, whereupon a vote was taken upon the original motion of Mr. Briggs, which was lost.

Upon motion the meeting adjourned.

WILLIAM H. WAHL, *Secretary.*

Proceedings of the Stated Meeting, June 18, 1873.

The meeting was called to order at the usual hour. In the absence of the President, Mr. Chas. J. Close was called to the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minute of the Board of Managers,

and reported that at the stated meeting held June 11th, 1873, the following donations to the Library had been received:

Geological Survey of Ohio and Maps. From the State Geologist.

Proceedings of the Scientific Meetings of the Geological Society of London for 1872, with Index 1861—1870. From the Society.

Monthly Reports of the Manchester Steam Users' Association for January, February, March and April, 1873. Annual Report of the same for 1872. From the Society.

Proceedings of the Royal Geographical Society of London, England, for May, 1873. From the Society.

Proceedings of the Literary and Philosophical Society of Liverpool, England, for 1871, 1872. From the Society.

Journal of the Society of Arts of London, England, for April, 1873. From the Society.

Journal of the Statistical Society of London, England, for March, 1873. From the Society.

A Compendium of the Ninth Census of the United States, June, 1870. From F. A. Walker, Superintendent of Census.

Smithsonian Contributions to Knowledge for 1873. From the Smithsonian Institution.

Annales des Ponts et Chausées for February, 1873. From the Editor.

The Actuary likewise reported the minutes of the several standing committees.

The special committees on the Horse-Power of Steam Boilers, and on Conflagrations, reported progress and were continued.

The President then announced a paper on Some Improvements in Weaving Machinery, by John Shinn. The paper gave a detailed description of a loom for weaving pile fabrics on stationary wires—the invention of the speaker,—an abstract of which will appear in the "Journal."

This paper was followed by one upon the American District Telegraph System. The subject was introduced and fully described by the Hon. Daniel M. Fox, after which a practical demonstration of its usefulness was made. The subject and remarks of the speaker are published in full in the "Journal" of September, 1873.

The Secretary next read his monthly report upon Novelties in Science and the Mechanic Arts.

Under the head of new business, the Secretary announced the

resignation of John H. Cooper as a member of the Board of Managers, and called attention to the clause in the by-laws of the Institute requiring such a vacancy to be filled. An election was thereupon ordered for a member of the Board, to fill the unexpired term of the gentleman resigned. The election resulted in the choice of John W. Nystrom.

After which the meeting adjourned.

WILLIAM H. WAHL, *Secretary.*

Fire-proof Construction.—At a recent meeting of the Franklin Institute, an improvement in the mode of constructing fire-proof floors and ceilings, combined with a system of ventilation, the invention of Mr. James Bounds, was exhibited. The invention consists of a truncated tile with the floor and ceiling surfaces in parallel planes, and overlapping the iron beams. The perforated sides of the tile, when in position, form a flue extending from wall to wall, connecting with flues in the latter—forming thus a series of ventilating flues, in which punctured register openings in centre of ceilings assist; and, in the event of fire, the system described is designed to afford an outlet for smoke and flame without injury to rooms above and below. The iron girders are isolated from the action of fire. The inventor claims that, from the simplicity of his construction, many expensive details in building may be dispensed with. It is further maintained that the tile by modification is capable of forming a level floor and ceiling arch without impairing either the fire-proof or ventilating properties of the construction, and that floors, roofs and partitions of any size, may be constructed upon the above plan.

The Suez Canal.—The returns of the Suez Canal Company for the month of August, according to the *Engineer*, make a very satisfactory show. It appears that 83 vessels passed through the canal during the 31 days of August, making an average of more than 2½ per diem, and yielding the company the sum of 1,660,000 francs transit receipts. The average cost per ship, it will be seen, by dividing the total receipts by 83, was just £800. It appears that the tonnage of the 25 vessels which passed through the canal during the third portion of the month made up an aggregate of 49,500 tons; if the other 58 vessels were of equal tonnage, the traffic must have been about 164,000 tons. The tonnage of the 25 vessels already referred to, gives an average of 1980 tons per ship, which shows that many of the vessels must have been of large size.